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THE NEW GRAVING DOCK OF THE KAWASAKI DOCK YARD CO. AT KOBE, JAPAN.

By Dr. Genjiro Yamasaki.*

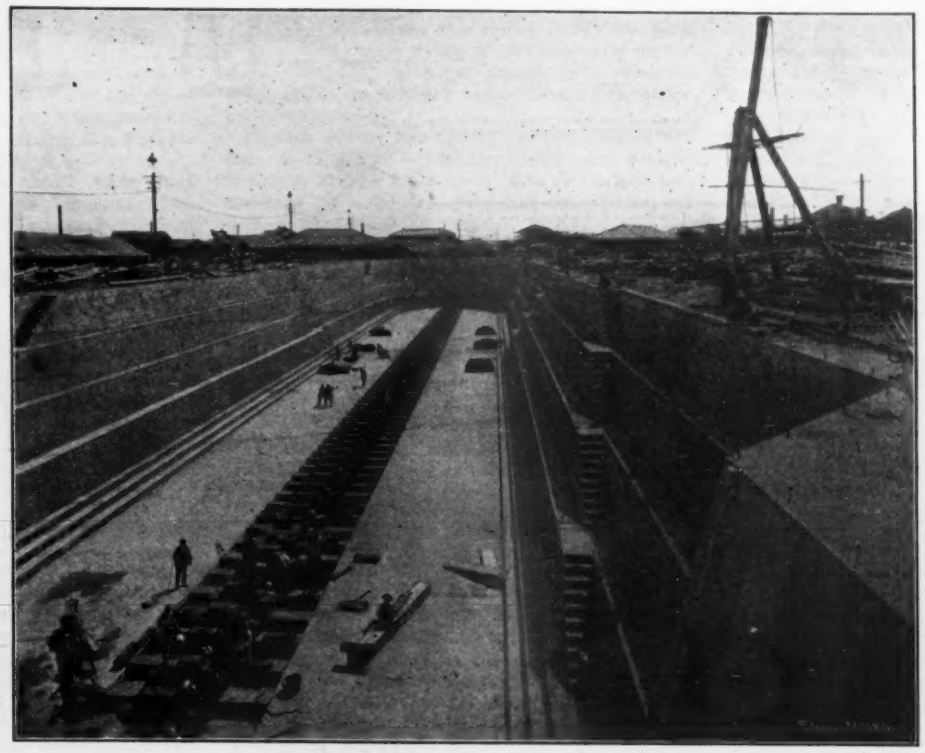
The Kawasaki Dockyard is situated near the mouth of the old Minatogawa in Kobe, which is at present the greatest trading port of Japan. While the dockyard was owned by Government, the need of a dry dock had already been felt, and several efforts had been made to select a proper site for one, but owning to the bad nature of ground along the general coast line of Kobe, the task of building such a structure was given up as an impossible achievement. The result was the construction of a patent slip in the dockyard which accommodated vessels up to 2,000 tons and which is still in good working order. A few years after, viz., in 1886, this dockyard was given over to Mr. Shozo Kawasaki, who still maintains an active interest in its welfare.

Owing to the sudden increase of trade in Kobe from about the year 1893 and to the consequent increase of large vessels frequenting the port, a dry dock became an urgent necessity to meet the requirements of these vessels. Investigation into the subject was, therefore, again taken up, and after a careful study of the nature of the ground and the methods of dealing with it, it was finally decided to start the work. Just at this time, October, 1896, the dockyard, which had been Mr. Kawasaki's property for about ten years, was transferred to a joint stock company, which is the present Kawasaki Dockyard Co., Limited. The president of the company is Mr. Kojiro Matsukata, son of Count Matsukata, ex-Premier of Japan, and the vice-president is Mr. Yoshitaro Kawasaki, son of Mr. Shozo Kawasaki.

The work was begun in November, 1896, and the first vessel was docked in June, 1902, thus taking nearly five and a half years for its completion. The general dimensions of the dock are given in the preceding table.

The dock accommodates vessels up to 5,000 tons; its capacity is equal to 20,760 tons at high water.

SITE.—The first idea was to build the dock in the northern corner of the yard, but after considering the arrangement of workshops, building slips, etc., it was decided to select the southeastern corner for its site. The area of the site thus chosen being too small for the dock, necessary space had to be obtained by reclaiming the foreshore. The line X Y in Fig. 1 shows the original coast line. As the easterly wind is the one to be most feared, the direction of the center line of the dock was turned as far north as possible, and that of the finished dock is north 46° 50′ east.



NEW DRY-DOCK OF THE KAWASAKI DOCKYARD CO. AT KOBE, JAPAN.
Dr. Genjiro Yamasaki, Chief Engineer

GEOLOGICAL NATURE OF GROUND.—Two borings on land, two borings on the fore-shore, and one test pit near the coast were driven to ascertain the geological nature of the ground. Altogether there is a slight inclination of the strata towards the sea, their general arrangements are:

From h.-w. spring tide (0) to — 20 ft.	Sand.
From — 20 to — 45 ft.	Silt.
From — 45 " — 51 "	Silt mixed with sand.
From — 51 " — 52 "	Broken granite.
From — 52 " — 73 "	Compact sand charged with water.

This — 73 ft. was the greatest depth ascertained by the borings, as the lower strata were fairly well known from the experience which Japanese artesian well borers had obtained while driving wells in the vicinity of the yard. According to their information, this sand stratum extends as far down as — 90 ft.; then follows another layer of silt about 33 ft. in depth to — 123 ft. below which there is another layer of compact sand. The depth of this sand stratum is not known, but it is certain that it extends as far as — 168 ft., the lowest limit ever reached in the vicinity of the site.

The silt layer, which lies below the uppermost sand stratum on land, forms the sea bottom on the sea part. This silt bottom was so soft that, while the boring was being done in front of the shore subsequently reclaimed, a boring rod, accidentally dropped, sank about 12 ft. by its own weight, and later, while constructing the cofferdam in this part, great trouble was experienced owing to the sliding in of the trench made for the puddle.

The test pit, sunk near the seashore, was 5 ft. in diameter and its wall was made of wooden planks strengthened inside and outside with angle irons and iron bands. When its lower extremity reached — 40 ft., or it was sunk about 18 ft. into the silt, the inside of the pit was dried up, and a wooden pile was driven. When the lower end of this pile was down to — 53 ft., water, which found its way along the pile, appeared, and it rose so fast in the pit that it was filled with water from — 26 ft. to within 9 ft. of its top edge (+ 1 ft.), or 18 ft. in 50 minutes, or at the rate of about 12 tons per hour. This water, which exists in the stratum of the compact sand, has a sufficient head to raise itself up to nearly high water level. It is a mixture of salt and fresh water and its level fluctuates in concord with the rise and fall of the tide on the outside sea. These facts show that it has a connection with the sea water in some way or other.

	Shaku.*
Extreme length, outer caisson stop to toe of wall at head	428.0
Length on the floor	392.0
Width of body at coping level (narrowest part)	79.8
Width of entrance at coping level	64.0
Width of entrance at bottom	52.0
Depth of sill below coping	28.0
Depth of sill below h. w. spring tide	24.0
Range of spring tide	5.5

*The shaku is almost equal to the English foot, it being equal to 0.9942-ft.; in this article "foot" is to be understood as "shaku."

*Chief Civil Engineer, Kawasaki Dockyard Co., Kobe, Japan.

COFFERDAM.—The geological nature of the ground being as above described, it was thought almost impossible to execute the work in the dry, but as the first step for the work it was decided to enclose the dock-site with a cofferdam, whose total length was 1,540 ft. (Fig. 1), and to adopt a pile foundation, beginning from one end and proceeding little by little and finishing the concrete bottom as the work went on. The puddle on the dam reached — 38 ft. on the reclaimed part and 24 ft. on the land part. On completion of the dam, which took place about a year after its commencement, when the water inside was pumped out to — 12 ft., a sinking of one section of the dam occurred, while, at the same time, a part of the bottom of the enclosed site was forced up above water and formed a small island, so to speak.

EXCAVATION AND WELL SINKING.—Such being the case, it was almost impossible to proceed with the original plan of working even if repairs were made to the dam, and it was decided to execute the excavation, piling, concreting, etc., all under water. As the first step in this task, 15 cylinders, each 12 ft. in diameter, were sunk; seven in front of the entrance, three along the north entrance side wall and five along the south entrance side wall. Those sunk in front of the entrance, were taken off (two of them partially) to form the entrance after the completion of the dock. Subsequently a row of six cylinders, each 10 ft. in diameter, were sunk in front of the row of seven cylinders, and the space between these two rows of cylinders was partly filled with concrete (to — 20 ft.) and partly with puddle to serve the purpose of a dam when the inside of the dock was pumped out for the facing. Eight cylinders, sunk along the side walls, were embedded in the concrete and formed a part of the wall. The space along the dock head, being very much limited owing to the public road, seven more cylinders were sunk along the head to serve the purpose of retaining earth. The depths to which these cylinders were sunk were — 49 ft. to — 53 ft. for the entrance part and — 48 ft. to — 49 ft. for the head part.

The cylinders were of composite construction of wood and brick, the lower 24 ft. (18 ft. in 10-ft. cylinders) being made of wood, and the upper 24 to 29 ft. of brick. They were all filled with concrete after sinking was completed.

While the cylinder sinking was executed on one hand, excavation was carried on on the other, which was all done by a Priestman dredger and steam winches. The depth of the excavation was — 41 ft. along the center line, gradually rising to — 38 ft. at the sides; where the pumping chamber and rudder well came, they were excavated to — 43 ft. The section No. 1, Fig. 2, shows the form, when the excavation was completed; this section also shows the general arrangement of the geological strata.

PILE DRIVING.—After the excavation was finished, as the necessary preparation for pile driving, a temporary staging (Fig. 3) was erected all over the site, the posts of which were driven at a distance of 12½ ft. both ways. Beams and cross beams being fixed on these posts, rails were laid longitudinally, on top of which frames for supporting pile drivers ran. Rails being laid on the upper face of these frames, pile drivers were able to move tranversely; thus pile drivers could be moved both longitudinally and transversely with respect to the dock. Nine drivers were used, and for their working 11 steam winches were set along the north side of the dock site.

The lengths of the piles ranged from 22 ft. to 25 ft., though at special places piles of over 30 ft. were used, and their diameter at the smaller end was 8½ ins. They were driven 2½ ft. c. to c. both ways. In addition, close piles of similar size were driven all round the site to provide against the escape of silt. They were all of pine and the total number of both foundation and close piles was a little over 10,000.

The rails on top of the staging being laid just at about high water level and the lengths of the piles being such as above stated, it became necessary to use false piles for driving, which were 38 to 41 ft. in length. Where timber is abundant such an awkward procedure of using false piles might not have been adopted; but here long piles are comparatively scarce and consequently dear, which condition led to the adoption of the method above mentioned. Of course, the use of false piles gave great trouble in driving, both from frequent breakage of the piles themselves and from their connections. The weights of the hammers used were from 1,700 to 1,900 lbs., and their fall was generally fixed at 10 ft., and the final penetration ranged from ⅛ to ⅜-in. The total average of number of piles driven per day per driver was 7.9; the minimum being 1, when men were not accustomed at the beginning, and the maximum 15.

Although extreme care was taken in driving piles, it was rather difficult to judge of their bearing power, especially as they were driven with the use of false piles, and it was thought prudent to appeal to the direct trial. Such trials were made at two random places by loading 100 tons—necessary reduction being made for the buoyancy—of pig iron on top of a wooden frame which stood on four piles. But although each pile had to bear 25 tons net, there was no appreciable settlement in any one of the piles at these places, while the maximum calculated load the piles would have to bear was 11 tons. The section No. 2, Fig. 2, shows the staging, frames, drivers, etc.

RUBBLE PACKING.—After the piles were driven, their heads were cut off and rubble stone was thrown in between them to the average

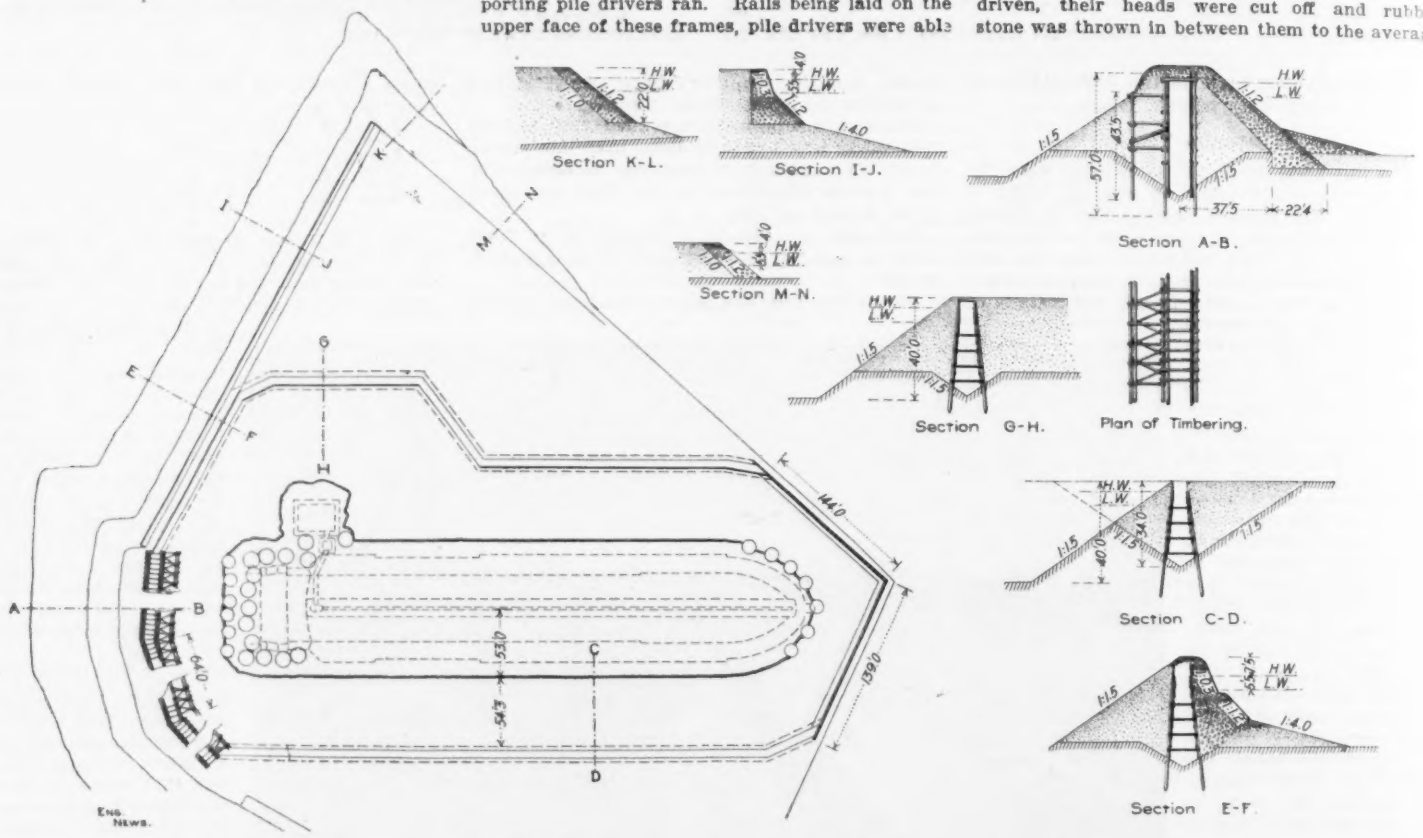


FIG. 1. PLAN OF SITE OF DRY-DOCK AT KOBE, JAPAN, SHOWING DETAILS OF COFFERDAM CONSTRUCTION.

thickness of 3 ft., leaving 1 to 1½ ft. of pile heads projecting above the rubble to be subsequently covered with concrete. When the rubble was well rammed in between piles with men on boats and with the aid of divers, it was found that soft silt oozed through the interstices of the rubble and settled on the top of it. This silt was so soft that it could not be removed with any kind of vessel, and it had to be sucked up with the aid of centrifugal pumps. Thus the ground was ready for concreting. The section No. 3, Fig. 2 shows the form at this stage of the work.

CONCRETE DEPOSITION UNDER WATER.—The injurious effect of sea water on cement concrete is now well known among engineers here. As concrete was to be deposited in its most unfavorable condition, namely, directly after its preparation, it was decided to change the water inside the dam to fresh water. Although the volume of water present in the dock site at that time was calculated at 80,000 tons, as it must be done gradually, over 310,000 tons of water from Kobe waterworks was required for this interchange of sea and fresh water, the latter entering from the surface, and the former being pumped out from the bottom, together with the scum produced by an unavoidable washing of mortar. The proportion of salt to fresh water was ascertained from time to time by analyzing water taken from

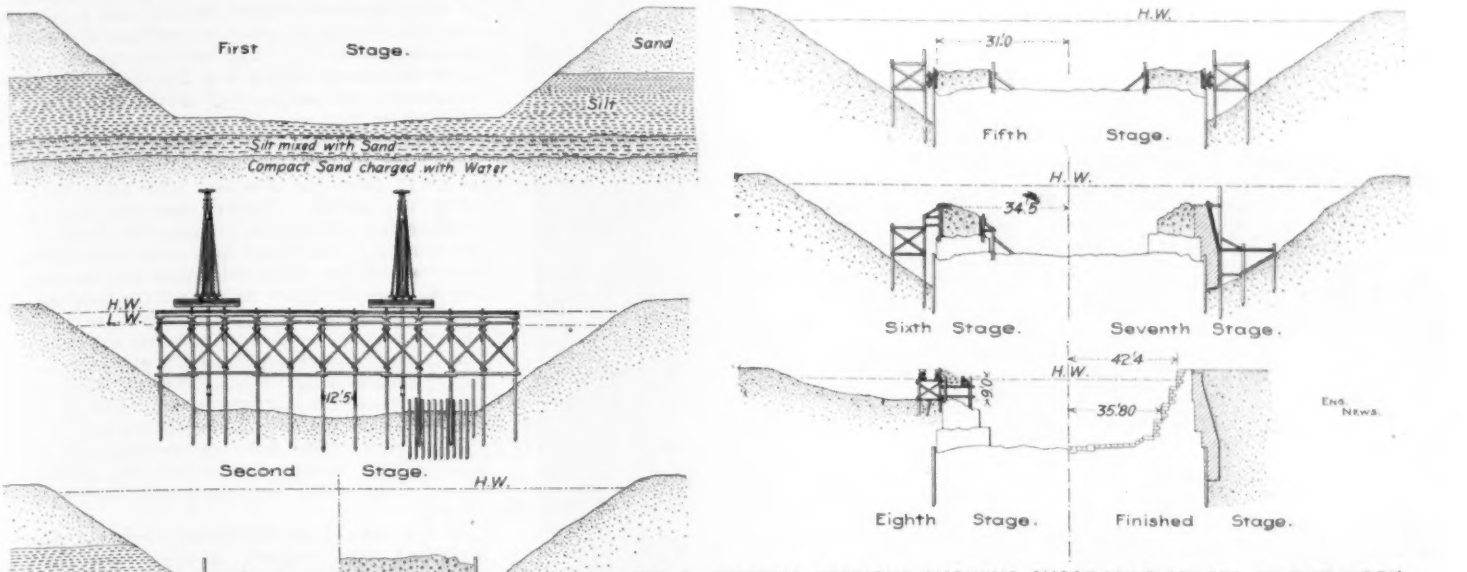


FIG. 2. DIAGRAM SECTIONS SHOWING SUCCESSIVE STAGES OF THE WORK.

reduced to 0.352 and 0.071 grams, respectively, at the end. The charging of fresh water gave also the advantage of maintaining the water level inside the dock site, so as not to injure the concrete in its imperfect state of hardening.

The deposition of concrete under water was started from the entrance side in the whole width of the dock bottom and to an average depth of 9 ft., which depth was previously ascertained by experiments. This deposition was accomplished by skips and cranes set on two pontoons, each carrying two hand cranes, men standing on the boats and on banks giving necessary directions as to the proper positions where skips were to be lowered. The skips were made of iron and had a capacity of 32 cu. ft. They were provided with canvas covering to minimize the washing of mortar during the sinking.

In order to secure the best possible union between the concrete, the work was pushed day and night without interruption. The divers were not allowed to disturb unset concrete and pumps were employed to take off the scum produced by unavoidable washing of mortar. The proportion of concrete for the bottom was 1 part mortar to 1 part gravel, and the mortar consisted of 1 part cement, 1 part puzzuolana, 0.19 part lime and 3 parts sand. The concrete used for the side wall had the proportion of 1 part mortar to 1½ parts gravel, and the mortar consisted of 1½ parts cement, 1 part puzzuolana, 0.25 part of lime and 4 parts sand. The concrete was mixed by three Carey-Latham concrete mixers of 10 cu. yds. capacity, and the mortar was prepared by 20 mortar mills of 6 ft. 6 ins. diameter. The setting time of mortar to be actually used was constantly observed in the cement testing room by immersing mortar in the water taken from the dock site, and its beginning ranged from 8 to 10 hours in water. The utmost care was taken in deposition to join new concrete to old, before the latter began to set. Fig. 2, section No. 4, shows the form of the bottom as actually determined by soundings.

After the bottom concrete was all finished, the next step was the deposition for side walls, and before it was commenced all dirt was taken off from the bottom concrete surface, minor dirt, scum, etc., were blown off by jets, and necessary frames to confine concrete to the designed form were erected; these were all erected by divers.

Concrete for side walls was deposited in two layers of 7 ft. and 12 ft. deep, the same care being taken for deposition as for the bottom. Sections No. 5 and No. 6 show the form of concrete for side walls, and the necessary frames erected for its deposition. This brought up the top of the concrete to 8 ft.

Concreting under water was stopped at this level of 8 ft. below high water, as by the previous experience it was certain that water inside the dock site, owing to the existence of the outer cofferdam, with the sunken part repaired, could safely be lowered to at least 10 ft. below high water level.

English cement was mostly used, supplied as follows: J. B. White & Brothers, 3,731 tons; Knight, Bevan & Sturge, 2,798 tons; Mikawa Cement Co., 550 tons. The factory of the last-named company is in the Province of Mikawa, Japan.

Puzzuolana was got from one of the Goto Islands (not far from Nagasaki), in the Province of Hizen. Gravel and sand used were mostly obtained from the sea coasts in the vicinity of Kobe. The total quantity of concrete deposited under water was 27,200 cu. yds., and the greatest quantity lowered in a day (24 hours) was about 640 cu. yds. The total number of men, divers, carpenters, engine drivers, coolies, etc., employed for this work only was 149,000, reduced to a day's work of 10 hours.

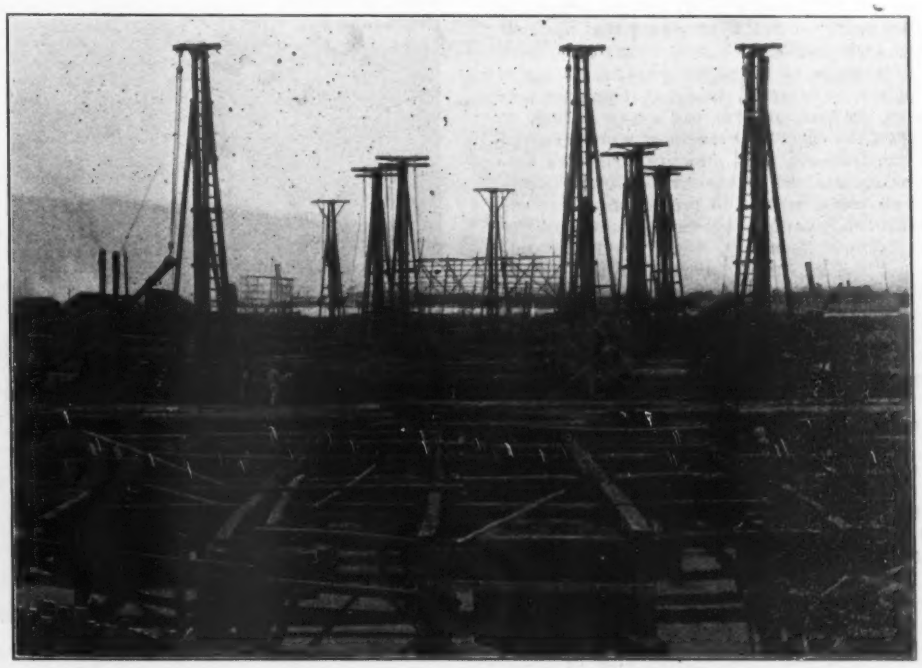


FIG. 3. VIEW SHOWING TEMPORARY STAGING AND PLANT FOR DRIVING FOUNDATION PILES.

PUDDLE AND PARTIAL FILLING.—The next step taken was to put in clay puddle directly on the back of the side walls all around the dock. Previous to the laying, all the frames hitherto constructed at the back for the deposition of the concrete walls were taken off, and new frames were erected in their places to provide for the bulging out of the puddle. The puddle was prepared by two pugmills driven by steam engines. The prepared puddle from those mills was made to fall into skips (same skips used for concrete) on boats lying alongside the bank, and was lowered into its destined spots, necessary precautions being taken to insure a water-tight joint with natural bed of silt. The actual thickness of the puddle became much greater than the designed thickness of 6 ft., and in some special places it became even about 8 ft., owing to its bulging, in spite of the existence of frames to sustain it and precautions taken to fill in sand as soon as possible to counteract its pressure. The clay used for puddle was got from Awaji Island.

The back filling of sand was carried on together with the puddle laying, care being taken that the surface of the sand should always be below that of the puddle, lest sand should find its way through interstices of planking into the space for the puddle. Puddle and back filling were temporarily stopped when they reached nearly the same level as that of concrete deposited under

water. This stage of the work is shown in Section No. 7, Fig. 2.

PUMPING, CONCRETING AND TEMPORARY LOADING.—The interior of the concrete box, so to speak, was thus shut up from the outside except above 8 ft. below high water level, and the water

FIG. 4. VIEW SHOWING CONDITION OF THE INSIDE OF THE DOCK WHEN PUMPED OUT FOR THE FIRST TIME.

inside the cofferdam was begun to be pumped out. When the water was lowered to — 8 ft. the top of the side wall appeared above the water, and it was further lowered to — 9 ft. on the outside of the dock and to — 12 ft. in the inside.

As the work was so constructed that there should not be any direct connection between the outside and inside of the dock, it was evident that had there been no fault either in concrete or puddle, there should not be any change in the water level inside this box. Several days' observations showed that the daily increase was only about ⅝-in., and this confirmed the belief that there was no appreciable leakage. Consequently had there been no upward pressure to lift the box or had the box been heavy enough to overcome that pressure in case such existed, the box would now have been in a stage to be safely emptied. Careful calculations, however, showed that it was not safe to do so, as the box was not heavy enough to counteract the upward pressure of water existing under the bottom. This pressure under the bottom was ascertained by the level of water inside 8-in. iron pipes, which, to provide for the case when the observations of the bottom pressure should become necessary, were previously imbedded in the rubble packing under the bottom concrete. These pipes had open ends and through the bodies of the last ones holes were perforated to make the ingress of water easier. They ran under the side walls and went up through them, and their upper ends reached above high water level. There were six such pipes, one at the head, two on the north side and three on the south side. The observations of water level in those pipes showed that water not only rose quite high up in them to nearly high water level, but undulated in concord with the undulations of the external tides, the only differences being in smallness of range and lateness of time.

The pressure existing under the bottom having thus been ascertained, concrete was further raised on the side walls in the dry (Section No. 7, Fig. 2) and, as this alone was not heavy enough, rubble and gravel were thrown inside the dock to serve as a temporary load. The total amount of rubble and gravel was 8,000 cu. yds., and thus the excess of the weight of the box above the bottom pressure became more than 12 tons per lin. ft. of the dock length.

All the precautions which were deemed necessary having thus been made, water was pumped out from inside the dock, and it was found that the leakage in the whole dock amounted to only 1 cu. ft. per minute, or less than two tons per hour. The photograph, Fig. 4, shows the dock when it was emptied for the first time.

MASONRY FACING.—Such quantity of water being almost nothing, the preparations for masonry work were at once started, and as the first step for that, a temporary scaffolding, which was to serve two purposes, of lowering concrete, mortar and stone, and of taking out the temporary load, was erected over the centre line of the dock, and after its completion the stone setting was commenced. Four cantilever cranes, which were designed and constructed in the dockyard, were made to run on the side walls; four derricks worked by steam; two 3-ton hand cranes, and

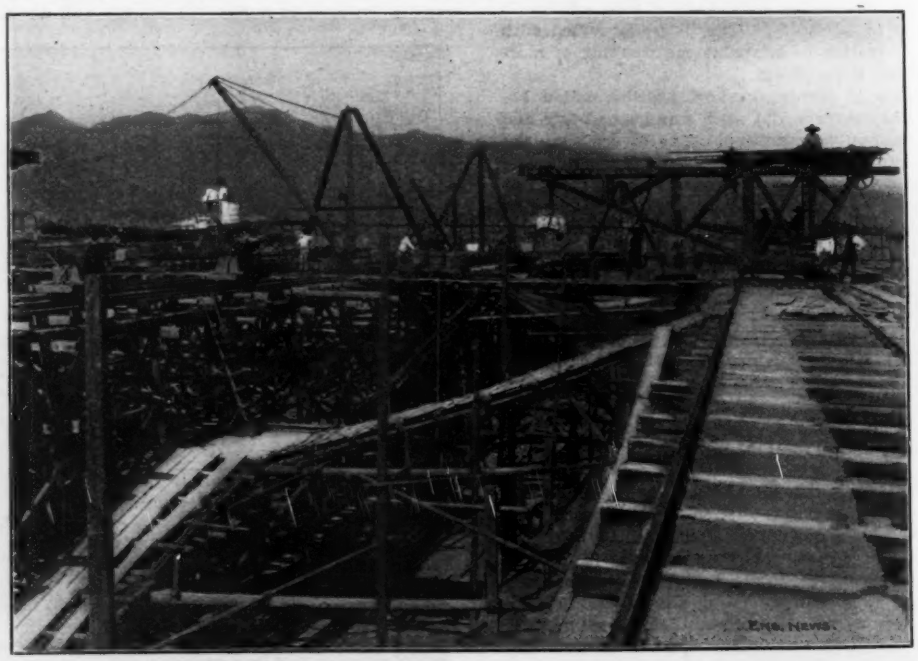


FIG. 5. VIEW SHOWING STAGING AND PLANT FOR LAYING THE STONE FACING.

two trussed beams, which were spanned between the central scaffolding and the side walls, were the principal machines used for lowering materials, setting stone and taking out the temporary load. This plant is shown by Fig. 5.

As the temporary load, above alluded to, was put in to compensate for the insufficiency of the weight of the concrete box, it could not be taken off at once, but had to be removed gradually as the stone facing progressed both on the bottom and the sides. This gave great trouble for working ,as the removal of the temporary load, leveling of irregularities of bottom surface with concrete and stone setting must all be done in a very limited space. Stone setting was commenced both from the entrance part and the head, and the greatest number set in a day of twelve hours was 1,310 cu. ft.

The facing stone was all of granite, mostly from Tokuyama quarry, and its thickness was from 1.3 to 2.6 ft. along the sides and from 1.5 to 2.5 ft. along the bottom. Special care was taken in building the entrance part, large-sized stones being used, and chains and rails being imbedded in suitable positions along the bottom and the sides. Mortar used for stone setting for the dock body had the proportion of 1 part cement, ¼ part puzzuolana and 2½ parts sand, and that for the entrance part had the proportion of 1 part cement to 1 part sand, both by volume. The only structures in connection with this dock in which granite was not used were the part of the culvert leading to the pumping house, penstock chamber, and the arch of the lower chamber of the pumping house, all of which were lined with hard burnt bricks.

On each side of the central drain 5-in iron pipes were laid with branches of 1½-in. iron pipes, which were to collect leaked water, though very slight, and discharge it to the rudder well.

PUMP HOUSE.—After the bottom concrete was deposited and set hard, a frame corresponding to the inner dimensions (allowance being made for facing) of the pump house was weighted down onto the bottom duct, an outer frame was erected outside of it leaving a space between them, which had to be filled with concrete under water and had to form the body of the wall. After the wall reached the proper height, the inside and outside frame were taken off. The inside was then faced with stone and the outside was backed with clay puddle. In that part of the side wall, where the culvert leading to the pump house had to pass, another frame was set down at the same time with that for the pumping house, and when, after the water was pumped out from the dock, it was removed, a tunnel was formed connecting the inside of the dock with that of the pump house, which tunnel was subsequently lined to form the culvert.

CAISSON.—The caisson is of the box-shaped type with four sluices of 20 ins. diameter for letting in water, and an electrically driven 5-in. cen-

trifugal pump is set up on it to give greater convenience for the removal of water ballast.

PUMPS.—The main pump is an electrically driven 30-in. centrifugal pump, the electricity being supplied from the main electrical station of the company. This is the first instance of the erection of a motor for this purpose in Japan. Besides this main pump, there are an 8-in. drainage pump and an air pump for starting the main pump, both of which are driven by electricity. This main pump has the capacity to raise 5,000 tons per hour and will lay dry the dock in about four hours. The pumps were those manufactured by the Lawrence Machine Co. and the motors were by the General Electric Co. All these were supplied by the American Trading Company. As there is no need of boilers, the pump house is very simple, its roof standing up only about 2.6 ft. above the ground level.

The dates at which the several works above described were commenced are:

First cofferdam	November, 1896
Excavation	November, 1896
Cylinder sinking	March, 1898
Piling	December, 1898
Concreting	April, 1900
Stone facing	July, 1901
The dock opened	June, 1902

The total cost of the work was 1,700,000 yen ($850,000).

The writer of this paper acted as Chief Engineer for the work, and his chief assistants were Samuru Maruta, M. E., and Jinzo Okamura. The drawing Fig. 6 shows the construction of the dock and the view on page 257 shows the completed structure.

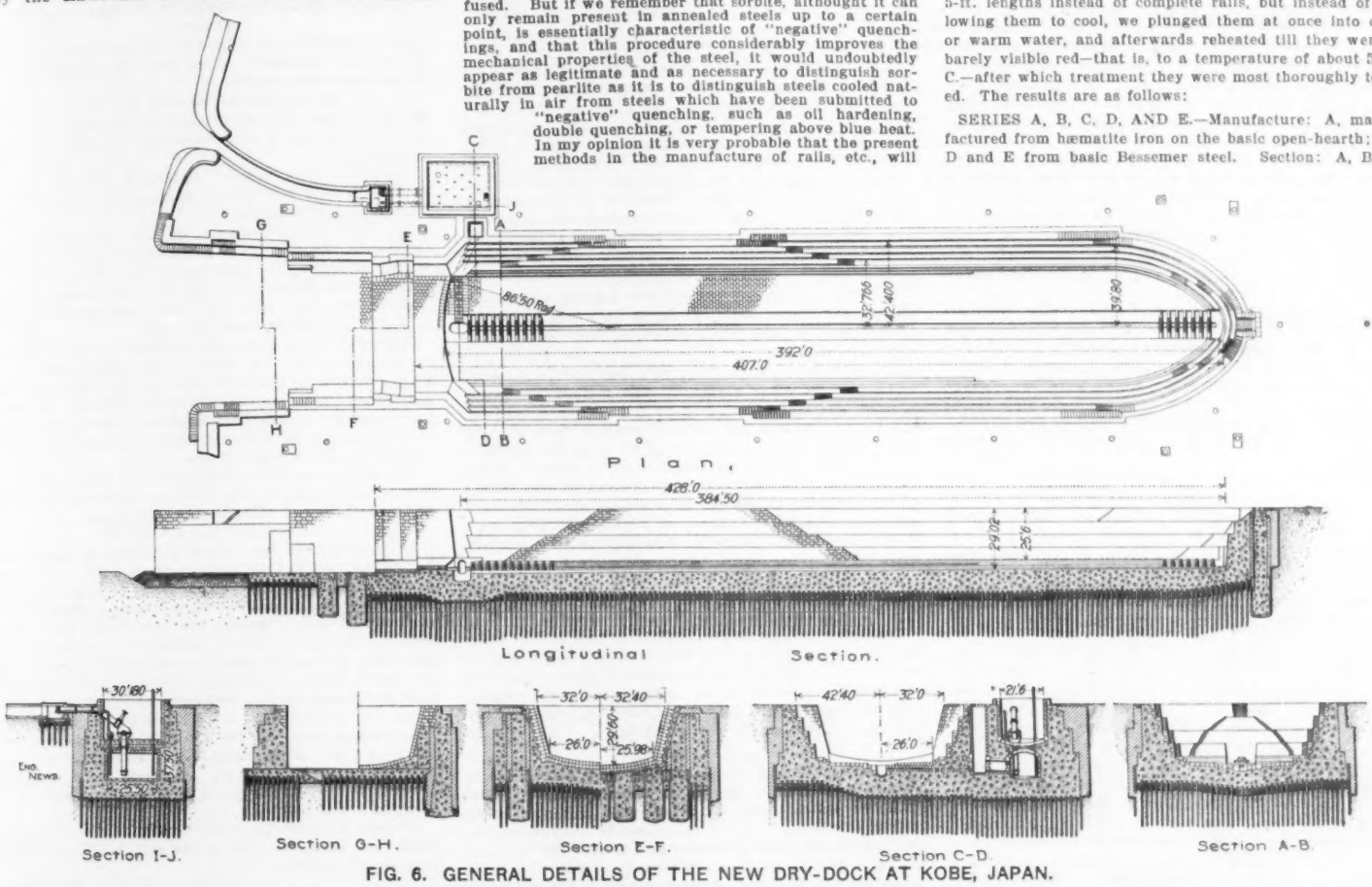


FIG. 6. GENERAL DETAILS OF THE NEW DRY-DOCK AT KOBE, JAPAN.

SORBITIC STEEL RAILS.*

By J. E. Stead, F. R. S.,† and Arthur W. Richards.‡

Exception has been taken by some that sorbite has not a sufficiently distinctive character to justify recognition of its individuality. It is pleaded that it is a transition condition of the carbide intermediate between the state in which it exists in hardened and annealed steels. It was eventually appear primitive, and I hope that the greater quantity of pearlite in our steel will be replaced in future practice by sorbite.

From the point of view of micrography, sorbite is characterized by the absence of striæ, and by the property of coloring rapidly by polish-attack, or by tincture of iodine, even when the latter is diluted with its own volume of alcohol.

So distinctive are the properties which this particular condition, or variable condition of the carbides in iron and steel, confers on steel that for years it has been the practice of steel manufacturers, at considerable expense, to oil-quench heated steel in order to obtain increased toughness and strength, and for wire manufacturers to "patent" their wire rods to arrive at a similar result. It is the sorbite produced which confers greater tenacity and toughness to the steels.

DESCRIPTION OF EXPERIMENTS IN MAKING SORBITIC RAILS.

On most carefully studying the effect of oil quenching on steel, we found, as was naturally expected, that the proportion of sorbite is great or small according to the size of the mass quenched. The central portions of large masses after treating contain much less sorbite than the exterior portions. If, on the other hand, the section of the steel quenched is very light, one may readily have in addition to sorbite some of the more brittle constituents of steel.

Similarly, when steel is air hardened, it may contain practically no sorbite if the mass of steel is great, and much of it if the section is slight. For instance, a wire rod ¼-in. in diameter and a fine wire made from the same steel containing 0.70% carbon, when cooled in air from the same initial temperature, say 850° C., become, the first sorbitic and tough, whilst the second will be in an intensely hard or brittle condition. Steel wire rods after passing through the patenting process, which consists in heating to a temperature at which the steel "scales" and then cooling more or less rapidly through the critical points, contain large quantities of sorbite, readily detected by the microscope after etching, or by the comparatively dark color the whole surface assumes when etched side by side with the rod before patenting. The property of enabling the patented rod to be drawn to a much greater fineness than is possible in the unpatented material is undoubtedly the effect of the sorbite present.

We naturally concluded that if sorbite is responsible for the excellent qualities of oil-quenched steel and negatively quenched steel wire rods, there is no reason why it should not be produced in steel rails, tire, etc., without great expense. With this object in view we first experimented on 5-ft. lengths instead of complete rails, but instead of allowing them to cool, we plunged them at once into cold or warm water, and afterwards reheated till they were a barely visible red—that is, to a temperature of about 500° C.—after which treatment they were most thoroughly tested. The results are as follows:

SERIES A, B, C, D, AND E.—Manufacture: A, manufactured from hæmatite iron on the basic open-hearth; B, D and E from basic Bessemer steel. Section: A, B, D and E, 60 lbs. per yard flat bottom rail; C 85.5 lbs. per yard bull-head rail. Analysis as follows:

	A.	B.	C.	D.	E.
Carbon	0.29	0.31	0.40	0.45	0.48
Manganese	0.72	0.72	0.73	0.57	0.82
Silicon	0.02	0.03	0.03	0.04	0.06

TREATMENT OF THE RAILS OF EACH SERIES AFTER CUTTING AT THE HOT SAW.—A1. Normal; allowed to cool down in air; A2. Quenched in hot water; reheated to 550° C., (16 mins.), and allowed to cool down in air; A3. Quenched in hot water; reheated to 500° C. (12 mins.), and allowed to cool down in air. B1. Normal; allowed to cool down in air. B2. Quenched in boiling water; reheated to 650° C. (30 mins.), and allowed to cool down in air. C1. Normal; allowed to cool down in air; C2. Quenched in hot water; reheated to 550° C. (40 mins.), and allowed to cool down in air. D1. Normal; allowed to cool down in air; D2. Quenched in cold water; reheated to 550° C. (50 mins.), and allowed to cool down in air; D3. Quenched in warm water; reheated to 500° C. (30 mins.), and allowed to cool down in air; D4. Quenched in hot water; reheated to 450° C. (30 mins.), and allowed to cool down in air. E1. Normal; allowed to cool down in air; E2. Quenched in hot water; reheated to 550° C. (40 mins), and allowed to cool down in air; E3. Quenched in hot water; reheated to 500° C. (25 mins.), and allowed to cool down in air; E4. Quenched in boiling water; reheated to 450° C. (40 mins.), and allowed to cool down in air.

The results of the mechanical tests were as shown by the table at the top of page 262.

In testing by Brinell's methods a number of impressions were made on each rail, and the results obtained were averaged, giving the hardness numbers stated in the table.

These results were so satisfactory that we proceeded with further trials, with the object of avoiding the reheating. As in the previous experiments, we used 5-ft. lengths of hot rails, but this time we plunged them into

*Abstract of a paper read before the Iron and Steel Institute of Great Britain.
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*See "Metallography," by F. Osmond. London: C. Griffin & Sons, Ltd., 1903.

Series No.	Treatment.	Impact test;* Deflection in ins. After first blow.	Impact test;* Deflection in ins. After second blow.	Tensile Test. Tons per sq.in. Yield point.	Tensile Test. Tons per sq.in. Ultimate stress.	Per cent. Elongation, in 4 ins.	Per cent. Contraction of area.	Hardness No.; Brinell's method.
A1	Normal	$3^{11}/_{16}$	$7^{3}/_{16}$	21.30	35.90	21.00	45.80	107
A2	Reheated, 550° C.	$3^{1}/_{2}$	$6^{5}/_{8}$	23.25	39.20	23.00	56.20	126
A3	" 500° C.	$2^{7}/_{8}$	$5^{1}/_{2}$	24.50	46.00	16.00	48.20	136
B1	Normal	4	$7^{5}/_{8}$	25.20	35.60	20.00	36.00	116
B2	Reheated, 650° C.	$3^{9}/_{16}$	$6^{13}/_{16}$	29.20	39.20	16.00	40.10	125
C1	Normal	$2^{1}/_{8}$	$3^{7}/_{8}$	26.60	41.10	18.00	35.50	147
C2	Reheated, 550° C.	$1^{11}/_{16}$	$3^{1}/_{16}$	27.10	46.70	16.00	36.00	164
D1	Normal	$3^{3}/_{8}$	$7^{5}/_{16}$	22.60	43.50	16.00	32.80	144
D2	Reheated, 550° C.	$2^{13}/_{16}$	$5^{3}/_{8}$	20.65	52.80	13.00	30.40	175
D3	" 500° C.	$2^{11}/_{16}$	$5^{1}/_{4}$	22.90	52.00	13.00	24.70	165
D4	" 450° C.	$2^{7}/_{16}$	$4^{13}/_{16}$	22.20	54.90	12.00	28.10	211
E1	Normal	$3^{1}/_{16}$	$6^{5}/_{16}$	23.10	45.20	13.00	22.10	169
E2	Reheated, 550° C.	$2^{11}/_{16}$	$5^{1}/_{16}$	31.90	51.10	15.00	40.20	177
E3	" 500° C.	$2^{9}/_{16}$	$4^{15}/_{16}$	34.90	58.90	11.00	23.90	197
E4	" 450° C.	$2^{5}/_{8}$	$4^{5}/_{8}$	32.00	64.50	7.00	10.75	222

*Weight of ball = 2,240 lbs. Distance of drop = 10 ft. Supports apart = 3.5 ft. Length tested = 5 ft. Diameter of ball = 10 millimeters. Load applied = 5,000 kilos.

cold water till they were nearly black; they were then removed and allowed to cool in air. During cooling, the heat still in the interior of the rails in passing outwards tempered the chilled portion, and left the external parts in the sorbitic condition.

We made many experiments, varying the conditions for each. In some cases we simply sprayed the heads; in others, we plunged the whole 5-ft. lengths of rail into water till the temperature was reduced to just visible redness, and in each case they were then allowed to temper themselves by cooling in the air. Experiments were also made to determine the effect of placing the heads to various distances under water.

We had often previously seen attempts made to improve the properties of rails by spraying them, but in no case was the water used in sufficient quantity to produce a material quantity of sorbite, and it invariably produced only carbide and ferrite areas, which were left occupying the same relative volume as if the same rails cooled naturally. There was, however, a distinct improvement in the strength, owing to a small quantity of sorbite present.

Our work has shown that a maximum quantity of sorbite can only be obtained by rapid cooling to below the critical points followed by tempering by external or the internal heat of the partially chilled steel.

SERIES F AND G.—Northeastern 90 lbs. bull-head rails, analyses as follows:

	F.	G.
Carbon, per cent.	0.49	0.45
Manganese, per cent.	0.69	0.79
Silicon, per cent.	0.02	0.02

TREATMENT OF RAILS OF SERIES F AND G.—F1. Normal; allowed to cool down in air; F2. The upper half of rail head quenched in cold water to blackness, then allowed to cool down in air; F3. The whole rail head quenched in cold water to dull red, then allowed to cool down in air. G1. Normal; allowed to cool down in air; G2. The upper half of rail head quenched in cold water to blackness, then allowed to cool down in air; G3. The whole rail head quenched in water until very dull red, then allowed to cool down in air.

The results of the impact tests were as follows:

Series No.	Deflection After 1st blow.	Deflection After 2d blow.
" " F1.	$1^{15}/_{16}$ ins.	$3^{3}/_{16}$ ins.
" " F2.	$1^{13}/_{16}$ "	$3^{3}/_{16}$ "
" " F3.	$1^{7}/_{8}$ "	$3^{1}/_{4}$ "
" " G1.	2 "	$3^{5}/_{8}$ "
" " G2.	$1^{15}/_{16}$ "	$3^{5}/_{8}$ "
" " G3.	$1^{7}/_{8}$ "	$3^{3}/_{16}$ "

Weight of ball = 2,240 lbs. Distance of drop = 15 ft. Supports apart = 3 ft. Length of rail tested = 5 ft.

The results of the tensile tests were as follows:

Series No.	Tons per sq.in. Yield point.	Tons per sq.in. Ultimate stress.	Per cent. Elongation in 4 ins.	Per cent. Contraction of area.	Hardness No.; Brinell's method.
F1.	23.50	37.20	19.00	28.80	158
F2.	31.10	44.40	16.00	35.00	1c2
F3.	33.30	45.20	10.00	30.50	187
G1.	22.50	36.50	22.00	28 00	145
G2.	30.70	47.50	16.00	35.80	193
G3.	32.00	49.00	13.50	30.00	204

The test piece of each treated rail was taken from the upper part of the rail head.

SERIES H.—60-lb. flange rails. In the following table N is the normal rail; S was sprayed with water imperfectly. The darkened parts, representing the sorbitic regions, indicate where the most water was applied; H S, only the head was plunged into water till it was cooled to a barely visible redness; W W, was plunged into water completely to barely visible redness.

In each case after the water treatment the rails were allowed to cool out on the rail bank to temper themselves. These experiments were made on Finland State rails for the engineer of the Finland States Railways. The analysis was as follows:

Carbon	0.38%
Manganese	.83%
Silicon	.025%

The test pieces were taken from the center of the rail heads, and do not, therefore, represent the properties of the upper layers of the rails where there was most sorbite. The results were as given in the table at the bottom of the preceding column.

Series No.	Impact test;* deflection after 1st blow, ins.	Tensile test. Tons per sq. in. Yield point.	Tensile test. Tons per sq. in. Ultimate stress.	Per cent. Elongation in 8 ins.	Per cent. Contraction of area.
N	$2^{9}/_{16}$	....†	43.60	17.00	32.00
S	$2^{3}/_{8}$	.....	44.20	16.00	31.50
H W	$2^{9}/_{16}$	.....	46.40	16.00	31.30
W W	$1^{9}/_{16}$	.....	50.70	11.50	28.00

*Weight of ball = 2,240 lbs.; distance of drop = 10 ft.; supports apart = 3.5 ft.; length tested = 5 ft.
†Not taken.

RELATIVE WEAR.

In order to ascertain the relative wearing property of pearlite and sorbite steels, we would have been glad if we could have presented actual results of wear on a permanent railway track over a period of several years. As this was, however, impossible, we endeavored to get some indications by other means. The method we finally adopted was that of grinding on a freestone grindstone, using equal surface pressure and distance traveled. In applying this test, we cut out pieces from the heads of both the rails ½-in. in thickness, and 1-in. square. These were carefully weighed, and were pressed on the surface of the revolving grindstone by a weight of 72 lbs. until they had traveled a distance of 20,000 ft. They were then removed and weighed. The tests were repeatedly made on the same pieces. The results are as follows:

	Average.
Pearlite rails	0.100
Sorbite	.33

The results are decidedly in favor of the sorbite rails. Whether or not they will be borne out in practice remains to be seen. It seems most reasonable to believe that such homogeneous material as the sorbite steel, much tougher than the same steel in the pearlite condition, will certainly last much longer on the permanent way.

SUMMARY.

The chief point of interest in our work is the simple method employed for producing sorbite in steel. The usual custom has been to reheat and oil-harden or to quench completely in water and reheat to dull redness. In our method we avoid reheating, and quench the heads of the rails, as soon as they are sawn to length, to a point under A r 1, and allow the residual heat in the rail to do the tempering. The results of the later experiments show clearly enough that by partially quenching the heads and allowing the rails to temper themselves, although the elongation is decreased, the contraction of area remains practically the same.

The normal rail in F series of 37 tons tenacity when made sorbitic is increased in strength to 45 tons without diminution of the contraction of area.

In G series the normal rail with 36½ tons tenacity is increased to 49 tons with a slight increase in the contraction of area.

In the last series (Series H) the tenacity is increased from 43 to 50 tons with a slight diminution in the contraction of area.

Pieces of the rail cut from the area of maximum sorbite on being tester by repeated reversals of strain showed greater toughness and endurance than the normal material.

The wear is very greatly in favor of the sorbitic material, as would naturally be expected, and we are sanguine enough to believe that by specially treating the rails in the simple manner described their life will be increased from 25 to 50%.

The splendid results obtained by Mr. Brinell on quenching steel from about 850° C. and reheating to 550° C., and the results quoted by Mr. H. Le Chatelier, and the evidence given by Mr. Osmond, together with what has been advanced in this paper, all point in one direction, and should lead every iron and steel metallurgist to aim at replacing pearlite by sorbite in all structural steels which have to be subjected to friction, percussion or vibration when in use.

Finally, we may point out that although it is quite easy to treat hot rails in short pieces, we have not yet completely succeeded in treating 30-ft. lengths satisfactorily. Our work is, however, far from complete, but we hope that before long we shall be able to report a complete success.

THE RESTORATION OF DANGEROUSLY CRYSTALLIZED STEEL BY HEAT TREATMENT.*

By J. E. Stead,† F.R.S., and Arthur W. Richards.‡

Having for several years devoted much time and attention to the effect of heat on the mechanical properties of steel, and having repeatedly restored dangerously crystalline steel in large pieces by simple heat treatment, and obtained material which would be accepted by any engineer in the country as excellent, we thought that an account of our work would probably tend to show that the so-called generally received impression, that dangerously crystalline material must be forged in order to restore it to good qualities, is, excepting in rare cases, quite unfounded.

VARIETIES OF DANGEROUSLY CRYSTALLINE STEEL.

In the course of our experience we have met with steel dangerously crystalline which may for convenience be divided into three classes.

The first class occurs only in mild steel very low in carbon and in pure iron; it is caused by annealing for a long period at too low a temperature in a slightly oxidizing atmosphere.

The second class, which is equally dangerously crystalline and is very common, is produced by long continued heating at high temperatures.

The third variety occasionally met with is produced by heating the steel till it is practically burnt. In other words, to a point so near fusion, that an evolution of gas occurs in the interior of the steel which separates the crystals from each other, so breaking up or making more or less discontinuous the whole mass.

The metal in the third class, although greatly improved by heat treatment, can never be thoroughly restored by simply heating it; but in the case of the steel of the first and second classes we have found no difficulty, by proper heat treatment, in making it equal and more often superior to the normal or forged steel which had been worked and finished at proper temperatures.

The work described in this paper has been confined to medium or structural steel, such as is generally used for the manufacture of rails, tires, axles, etc.

EXPERIMENTS ON RAILS.

As exception has been repeatedly taken to experiments having been made upon small pieces of steel, and allegations made that if larger masses were to be used the results would be quite different, we made a series of experiments on rails of various sections. These were tested, first, in the normal state; second, in the dangerously crystalline state (a condition readily produced by heating the steel to between 1200° and 1300° C.); and, third, after such brittle material had been reheated to temperatures between 850° and 900° C., and allowed to cool in air. The tests applied were as follows: (1) Chemical analysis; (2) impact or falling weight test; (3) tensile test; (4) Brinell impression test; (5) Vibratory stress test; (6) Microscopic examination; (7) specific gravity. The results obtained are as follows:

SERIES A.—Bull head rail, 80 lbs. per yd., manufactured from haematite iron by the acid Bessemer process; analysis as follows:

	Per Cent.
Carbon	0.43
Manganese	1.01
Silicon	0.05
Sulphur	0.094
Phosphorus	0.065

(A1.) This was a complete rail, 30 ft. long, and had been allowed to cool down in air without treatment. This rail was subjected to an impact destruction test; with weight of ball, 2,240 lbs.; distance of drop, 20 ft.; bearings apart, 3.5 ft.; length of rail tested, 5 ft. Fourteen blows were given, the rail being reversed after each blow, and not showing any signs of fracture. It was then nicked and broken. This result confirms previous evidence that high sulphur or about 0.1% is not objectionable in sound steel rails.

(A2.) A short piece was cut from the rail at the conclusion of the above test. This was overheated for 2½ hours at 1,200° C., and allowed to cool down in air, and was divided into two equal parts.

(A3.) Part of the reheated rail A2 was slowly heated to between 850° and 900° C., and allowed to cool down in air, and was kept at that temperature in the furnace 40 minutes.

(A4.) A piece of the original rail, 5 ft. long, was rapidly

No. of Experiment	Treatment	Yield Point Tons per Sq. In.	Ultimate Stress. Tons per Sq. In.	Elongation per Cent. in 4 Ins.	Contraction of Area per Cent.
A1	Normal	20.00	41.00	22.00	38.90
A2	Overheated	22.10	45.90	14.00	19.60
A3	Restored	24.00	43.30	19.00	34.80
A4	Heated to 1100° C.	21.90	43.20	22.00	42.40

*Abstract of a paper read before the Iron and Steel Institute of Great Britain at the Barrow meeting.
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heated to a temperature of 1,100° C.; it was left in the furnace for 12 minutes, and was then allowed to cool down in air. When cold it was tested to destruction by the impact test; with weight of ball, 2,240 lbs.; distance of drop, 20 ft.; supports apart, 3.50 ft.; length of rail tested, 5 ft. Eighteen blows were given, the rail being reversed after each blow. The rail broke at the nineteenth blow.

The table at the bottom of the preceding column shows the results of the tensile tests. In each case the test pieces were cut from the center of the rail head.

Appearance of Tensile Fractures: A1. Fibrous. A2. Fracture was very largely crystalline, with no trace of fibrous structure; the crystals were somewhat larger in the centre than on the outer portion of the test piece. A3. Fibrous; very fine, and having a silky appearance. A4. Fibrous; structure much finer than A1; very dull in appearance.

SERIES B, C, D.—The section was the same for all series, viz., 90 lbs. per yd. bull head rail (North-Eastern Ry. Section). The rails of each series were manufactured as follows: (B.) Made from haematite iron on the basic open-hearth, and represents the normal composition for North-Eastern rail specifications. (C.) Bessemer steel; was specially selected because of the high phosphorus present. It had been put to one side as unsuitable for making rails. (D.) Made from haematite iron on the basic open-hearth; was specially selected on account of the high manganese. The following are the analysis of the these rails:

	B. Per Cent.	C. Per Cent.	D. Per Cent.
Carbon	0.45	0.36	0.46
Manganese	0.77	0.61	1.22
Silicon	0.04	0.02	0.02
Sulphur	0.064	0.075	0.05
Phosphorus	0.06	0.11	0.07

Each series comprised three rails, which were cut at the hot saw immediately after rolling, and were allowed to cool in the air. The schedule of tests was as follows: B1. Normal rail as rolled; tested without further treatment. B2. Overheated at 1,300° C. for 1½ hours, and allowed to cool down in air; this piece was divided into two parts when cold; B3. Part of B2 was again heated, and kept at a temperature of between 850° and 900° C. for 1 hour, and cooled down in air. C1. Normal rail as rolled; tested without further treatment. C2. Part of C1; overheated at 1,200° to 1,300° C. for 1½ hours, and allowed to cool down in air; this piece was divided into two equal parts. C3. Part of C2 was again heated, and kept at a temperature of 850° to 900° C. for 2 hours, and was cooled down in air. D1. Normal rail as rolled; tested without further treatment; D2. Part of D1; overheated at 1,200° C. for an hour, and cooled down in air; it was then divided as in previous series. D3. Part of D2 was again heated, and kept at a temperature of 850° C. for 2 hours, and cooled down in air.

The following are the results of the impact tests:

Series No.	Treatment	Deflection after 1st Blow Ins.	Deflection after 2d Blow Ins.	Deflection after 3d Blow Ins.
B1	Normal	1⅞	3¼	4 7/16
B2	Overheated	Broke	....	....
B3	Restored	1⅞	3 5/16	4⅛
C1	Normal	1 5/16	3¼	4⅛
C2	Overheated	Broke	....	....
C3	Restored	1⅝	3⅛	4⅛
D1	Normal	1 5/16	2 5/16	3 1/16
D2	Overheated	1 5/16	Broke	....
D3	Restored	1 5/16	2 5/16	3¼

Note.—All rails were allowed to cool down to ordinary temperature before testing. Weight of ball, 2,240 lbs.; distance of drop, 10 ft.; bearings apart, 3.5 ft.; length of rail tested, 5 ft.

The following are the results of the tensile tests. In each case the test pieces were cut from the centre of the railhead:

Series No.	Treatment	Yield Point. Tons per Square In.	Ultimate Stress. Tons per Square In.	Elongation per Cent. in 4 Ins.	Contraction of Area per Cent.	Average Hardness No. —Brinell's Method— Ball 10 mm. diam. Load 5000 kilos.	Ball 10 mm. diam. Load 50,000 kilos.
B1	Normal	20.40	40.10	18.50	29.50	150	148
B2	Overheated	32.40	39.40	14.75	15.50	147	142
B3	Restored	24.40	40.80	28.00	36.60	153	156
C1	Normal	19.35	38.10	25.00	37.60	133	149
C2	Overheated	20.30	37.40	21.00	20.70	132	144
C3	Restored	20.60	37.10	26.00	39.20	150	160
D1	Normal	28.10	50.80	11.00	12.50	210	209
D2	Overheated	26.90	50.10	7.00	6.00	190	191
D3	Restored	30.00	50.80	16.00	24.40	218	209

Appearance of Tensile Fractures: B1. Coarsely fibrous. B2. Entirely crystalline. B3. Fine; closely fibrous. C1. Coarsely fibrous. C2. Crystalline. C3. Fine silky fiber. D1. Finely granular. D2. Coarsely crystalline. D3. Finely granular, with indications of a tendency to fibrous structure in the centre of the test piece.

SERIES A.—We must observe that series A was the first rail on which we experimented with a view to restoration, but, judging from the structure of the fracture, it was evident that the heating had not been sufficiently elevated. The results of testing also confirm that view. The pyrometer in this case most probably had not been correctly interpreted. In the following trials the results are most satisfactory, for in the B series the restored rail showed an increase in tensile strength of 0.7 ton per sq. in., an increase in elongation of 9.5%, and an increase in the contraction of area of 7.1%. The C series showed a decrease in tensile strength of 1 ton per sq. in., with an increase in elongation of 1%, and an increase in contraction of area of 1.6%. In the D series the tensile strength remained the same, but the restored rail showed an increase in elongation of 5%, and an increase in contraction of area of 11.9%.

SERIES C.—This experiment was made from a cast in stock which had an unsuitable analysis for specifications, but we thought it would be interesting to take a rail ingot from this containing, as it did, sulphur 0.075% and phosphorus 0.11%, and subject it to the same treatment and tests as the others. It will be noted that although the carbon is much lower than in the rails of the A and B series, the tensile strength in the normal rail is only a little below the others, but the elongation is considerably better than either, and the contraction of area is equal to that of the A series and is 8.1% better than that of the B series, although the phosphorus is above the specified limit. The steel is proved by the mechanical tests to be excellent material in every respect.

EXPERIMENTS ON 5-IN. BLOOMS.

As the experiments with rails were so successful, another series of trials was made on a much larger mass of steel. A long steel bloom, 5 ins. square, was cut into 5 ft. lengths. One piece was tested in its normal condition without any treatment; two pieces were heated for four hours to a temperature approaching 1,400° C., and were then taken from the furnace and allowed to cool on the mill floor. One of these pieces was tested without further treatment. The second or duplicate overheated piece was reheated again to about 850° C. for two hours; it was then removed from the furnace and allowed to cool in the air. The results are appended below.

ANALYSIS.

Carbon	0.38 per cent.
Manganese	0.81 "
Silicon	0.04 "
Sulphur	0.062 "
Phosphorus	0.06 "

IMPACT TEST.

Series No.	Treatment	Deflection after 1st Blow Ins.	Deflection after 2d Blow Ins.	Deflection after 3d Blow Ins.
E1	Normal	2½	3⅝	5¼
E2	Overheated	Broke	....	....
E3	Restored	1¾	3 5/16	5 5/16

Weight of ball = 2,240 lbs. Distance of drop = 30 ft. Bearings apart = 3.5 ft. Length of billet tested = 5 ft.

TENSILE TEST.

Series No.	Treatment	Yield Point. Tons per Square In.	Ultimate Stress. Tons per Square In.	Elongation per Cent. in 4 Ins.	Contraction of Area per Cent.	Average Hardness No. —Brinell's Method— Ball 10 mm. diam. Load 50,000 kilos.	Ball 10 mm. diam. Load 5000 kilos.
E 1	Normal	26.20	42.10	24.00	45.80	159	144
E 2	Overheated	26.80	42.80	12.00	13.40	151	133
E 3	Restored	30.20	42.30	25.00	30.00	159	148

Note: In each case the test piece was cut from the central portion of the billet. Appearance of Tensile Fractures: E1. Coarsely granular. E2. Entirely crystalline. E3. Finely granular.

RESISTANCE TO REPEATED ALTERATIONS OF STRESS.

The process of testing metals by alternate straining has long been in use in steel and wire works, and some wire manufacturers claim that by the hand-bending test alone they can satisfactorily determine the quality of wire. We decided to test our samples by the Wohler system, applying stresses below or slightly above the elastic limit. Instead of using comparatively long bars, we have found it very convenient to employ short pieces of steel 3 or 4 ins. long and ½ in. in diameter, in the center part of which a groove is turned to reduce the diameter to ⅜ in., or to 1 centimeter.

SWEDISH IRON.—A bar ⅝-in. in diameter was placed in a liquid mass of haematite blast furnace slag weighing about 4 tons, and was allowed to cool down with the slag. When cold the slag ball was broken up and the bar removed.

By this treatment, in which the iron was heated out of contact with air to about 1,300° C. and was cooled very slowly during a period of three days, it was made most dangerously crystalline. One portion of it was tested in its brittle condition. A second portion was tested after simply reheating to a yellow heat and allowing to cool on a metal plate. The original bar was also tested, with the following results:

Resistance to Vibratory Stresses.—Number of reversals of equal stress, 19 tons per sq. in., required to produce fracture:

	1st Test.	2d Test.
Original bar	50,710	51,170
Slag annealed	19,980	22,200
Restored by heating	541,040	..

The remarkable result obtained with the Swedish bar, indicating, as it does, an enormous improvement, by being first made as brittle as cast-iron and then reheated, requires explanation. The original bar is not, we believe, designed for structural material, but is regularly used for melting in crucibles. It contained small plates of cinder cutting up the mass into sections, and in all probability the heat given to it originally at the works where it was made was not sufficiently strong to perfectly weld the particles of iron together. The effect of the very strong heating in the slag ball caused the enclosed cinder to melt and to behave exactly as do irregular-shaped drops of oil when thrown into alcohol; they assumed the globular form, and were found in the cold metal as minute spherical masses. The metal itself had become perfectly homogeneous and continuous in structure, resembling that of pure melted iron, with the difference that the former contained the isolated globules of cinder, while in the latter there is none.

SOFT BASIC STEEL.—This sample consisted of a bar 2 ins. square which had been made brittle by long continued heating at a high temperature. One portion was reheated to 950° C., and was allowed to cool in air. A second portion was reheated and was forged down to a 1½-in. square bar.

Resistance to Vibratory Stresses.—Number of reversals of equal stress, 19 tons per sq. in., required to produce fracture:

Brittle bar	14,947
Restored by reheating	158,143
Reheated and hammered	153,315

It was hoped that many more vibratory tests would have been ready for insertion in the paper, but it has been found to be impossible. The results, however, all point in one direction, viz., that dangerously crystalline and brittle steel can be changed to very high-class material, possessing great power of resisting vibratory stresses, by simply heating to between 850° and 900° C., and without the necessity of forging to a smaller size. The results of vibrating, etc., heated and forged basic steel would lead to the conclusion that forging embrittled steel is not advantageous, but we hesitate before making many more tests to state that such is always the case. We know for a fact that wrought iron containing above 0.2% phosphorus, after embrittling, is not fully restored by reheating only. It is necessary to forge as well as to heat in order to remove the brittleness.

CONCLUSIONS.

In reviewing our work we believe that the following facts have been firmly established:

(1.) The microscope in each experimental series indicates the same result, that heating at high temperatures causes a great development in the size of the crystalline grains, and reheating to about 870° restores the original or a better structure.

(2.) If all structural steels in their normal rolled or forged condition are good, they can be readily deteriorated in quality by heating to a temperature a little above that to which steel is most commonly heated previous to rolling or forging.

(3.) Steel made brittle by such heating and dangerously brittle by heating at considerably higher temperatures can be completely restored to the best possible condition without forging down to a smaller size or by remelting.

Practically all our results show that not only are the original good qualities of normally rolled steel, after making brittle, restored by the exceedingly simple treatment of heating to about 900° C. for a very short time, but that such steel is made considerably better than it was.

It is scarcely necessary to say how important and far reaching to steel workers and engineers this most valuable knowledge is.

That brittle "soft steel" can be restored by reheating has been proved by one of us, and confirmed by Professor Heyn, Mr. Ridsdale, and is well known in Sweden,

but that carbon steel can be actually made much superior to the original properly forged metal by reheating to 870° and cooling in air is revealed at this meeting for the first time. It will be remembered that one of us at the Düsseldorf meeting last year urged upon those to whom it might concern the imperative necessity of reheating to 900° C. all forgings, and allowing them to cool in the air to remove accidental brittleness. The results given in this paper fully justify the statements then made. We would further urge that in every large forge and smith's shop Le Chatelier pyrometers should be introduced and in addition suitable furnaces for reheating the forgings, and that these should be systematically made use of.

From our own somewhat extensive experience we know for a fact that in many works steel is forged, rolled and finished at temperatures far above what is the best for the endurance of the steel when put into practical use, and we feel confident that if such appliances were to be intelligently employed the finished forgings would be greatly improved. It must be acknowledge that it has been upon the inferior enduring properties of such material that engineers have had to base their factors of safety, with the inevitable consequence that on the average much greater margins have been allowed than would be necessary if the steel were invariably obtained in its maximum condition of strength and safety. We are sanguine enough to believe that, as research advances, that enviable goal will ultimately be reached.

The work presented is certainly a movement in that direction, but we hope that by treating steel so as to obtain in its a large proportion of sorbite, still nearer shall we be to the highest aim of the metallurgist of iron and steel. We aim at making material which will be twice or three times as enduring as that commonly made to-day, and we believe that we shall be able eventually to make it.

(4.) We are convinced that the system often specified by engineers that forgings when being annealed shall not be heated to a temperature high enough to cause a scale, is wrong; 870° C. is coincident with a blue scale, and the steel is improved by heating till it forms this scale.

(5.) When the forgings are of unequal section they may be heated to 850° C. to 900° C., and be then cooled in air, be oil quenched, or be treated by any other Sorbyizing process till they are a barely visible red, and finally annealed in a furnace at a dull red heat to remove the stresses produced by rapid cooling.

A SEVERE FLOOD TEST OF AN EARTH DAM AT NEW CASTLE, PA.

By G. B. Zahniser.*

In 1900 the Graceland Cemetery Association, of New Castle, Pa., decided to make an artificial lake of about two acres at the main entrance to their cemetery. This was done by damming a small stream that flowed through their grounds in a ravine just south of their main gate (Fig. 1). The location of the dam was made at a point where the opposite banks of the ravine were about 150 ft. apart and where the natural surface of the ground was about 10 ft. below the proposed crest of the dam.

A test pit showed loose gravel and sand 4 or 5 ft. below the natural surface; then 6 ft. of blueish, yellow clay. After cutting a small hole through this clay, an iron bar was pushed and driven about 8 ft. deeper without striking any material that looked good. Money available for building the dam was limited and the stream reached the river below by a deep ravine, so it was decided to begin on the clay strata.

A trough 2 ft. deep and 2 ft. wide was dug in the clay and a 2-ft. concrete core wall built up to within 2 ft. of the crest of the dam, except for 10 ft. on each side of the spillway, where the

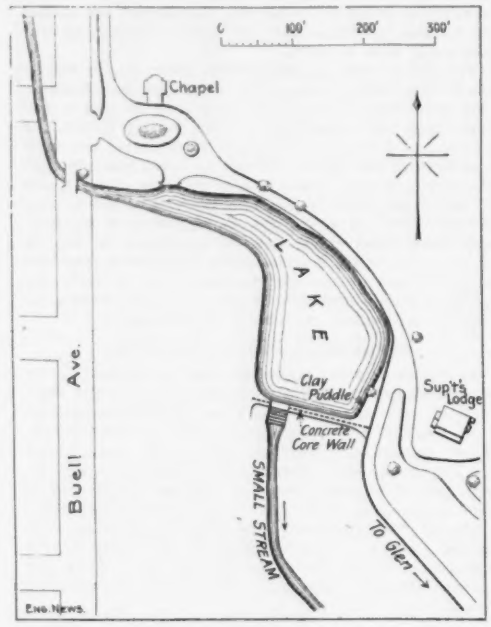

Fig. 1. Sketch Plan of Reservoir and Dam of Graceland Cemetery Association, New Castle, Pa., Overtopped by Flood on Aug. 27, 1903.

core wall was carried to the crest level. The spillway was 22 ft. wide and 4 ft. deep, with straight, vertical 2-ft. wide concrete side walls, and was located over the original thread of the stream.

The upstream approach was paved with 6 ins. of small drift boulders, of which there were many along the bed of the stream. The floor of the spillway was stepped down with 3-ft. rise, 4 ft. 6 ins. tread steps made of the same stone imbedded in cement mortar, and there was an apron 4 or 5 ft. deep and a roughly riprapped basin below.

The top of the dam was 6 ft. wide with 1½ : 1 slopes each way. It was the intention to make a rock fill since stone enough to do so was near at hand, but it became necessary to waste dirt from building the drive around the side of the lake; so this dirt tamped in 6-in. layers was used for filling. The men and teams that graded the road were used at the same time in building the dam.

A 16-in. waste pipe imbedded in a 2 × 2-ft. concrete box was located just back of the West spillway and the valve stem came up in a 4-in. sewer pipe through the core wall.

On the west side of the ravine the core wall was carried about 10 ft. into a very hard cemented gravel that made a very satisfactory anchor. On the east side of the ravine the core wall was carried 15 ft. into a gravel hill and nothing resisted but small loose gravel. It was this east end that worried the engineer.

When the lake was first filled the east end of the dam leaked terribly and the water ran around the end of the core wall through the gravel and came up in small streams all along the ground below. The lake was emptied, a 2-ft. ditch was dug along the east side of the lake just at the water line from the dam northward for about 80 ft. and down to the 6-in. clay strata. This ditch was filled with clay puddle rammed to place. All the slopes were then sodded to the water line and riprapped below. The lake was then refilled. The leakage at the east end was still found to be considerable, but so much of it had been stopped that the engineer was satisfied that the source of the leakage had been located. He decided to trust to the sediment brought down by the swift little stream that fed the lake to complete the sealing of the dam. This the sediment did so effectually that in three months no leakage whatever could be discovered.

On the night of Aug. 27, New Castle and the vicinity was visited by the hardest continuous rain storm in its history. Paved streets of 10% grade, 30 ft. between curb lines with 7-in. gutters ran curb-full for 20 minutes at a time. A street on a fill 30 ft. wide and 50 ft. high with a 3 × 4-ft. box culvert through the fill, washed out entirely for 150 ft. The roof of a barn lodged in the spillway of the cemetery dam described above and the water rose 4 ft. above the top of the dam, remaining thus for over an hour.

The fill on the lower side of the dam was washed out clear and clean to the face of the concrete core wall for the length of the dam. Strange to say, the 2 ft. of fill and the sod on top of the core wall remained intact and the dam and spillway held.

The views, Figs. 2 and 3, were taken Sept. 5, before any repairing had been attempted. Fig. 2 shows the extent of the damage from the downstream side. Fig. 3 shows the dam from upstream just after the lake was drained to ascertain the extent of the damage. The two trees on either side of the spillway in this picture were washed away and reset.

The cost of the dam and roadway around the lake was $2,500. The work was done by the day with a gang of men and foreman; the same gang doing work all over the cemetery. Of this cost $1,500 would fairly represent the amount chargeable to the dam.

Fig. 2. View of Spillway After Flood.

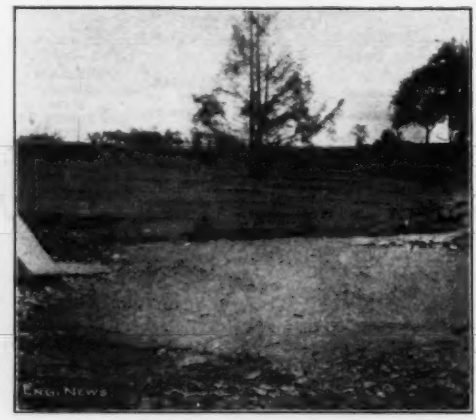

Fig. 3. View of Downstream Side of Dam, Showing Core Wall of Concrete, Exposed by Flood.

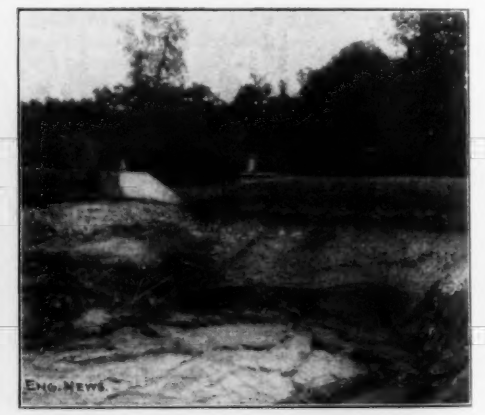

Fig. 4. View of Upstream Side of Dam, Showing Undisturbed Earth Filling Back of Core Wall.

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FALL MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

Two rather special occurrences marked the fourth general meeting of the American Electrochemical Society held at Niagara Falls, N. Y., on Sept. 17, 18 and 19. One of these, not directly concerning the society, was a meeting of the commission which has been appointed to arrange for an international electrical congress to be held at St. Louis next year. The executive committee of this body held its first full session at Niagara Falls on Sept.

18, and planned the general line of action for assembling this congress and directing its work. It is proposed to ask, through the government of the United States, that all civilized governments send official delegates to St. Louis for joint discussion of international electrical standards and units. Simultaneously with this convention there will be a general congress of electricity which, divided into a number of separate sections, will cover the entire field of electricity. It is planned that the leading national electrical societies shall officially take part in this congress.

The other special occurrence was the acceptance by the American Electrochemical Society of the "local section" idea, which hitherto has been exploited by only one of the national engineering societies. A request was submitted by the Madison, Wis., members of the society for permission to form a local section. This request was granted by the directors of the society, who further announced it their policy to grant all future requests of like character. Local sections are believed by them to be of great value as a means of extending the usefulness of the society and increasing its membership. It is probable from informal opinions expressed by members of the society that steps will soon be taken to form a New York section.

The meeting in general was very satisfactory, especially in view of the fact that the meeting of a year ago was also held at Niagara Falls. The great number of electrochemical and similar plants located there operates as a strong attraction for a society of this kind, though the majority of these plants are kept tightly closed to visitors. The society has a large local membership in Niagara Falls, and this helped to swell the list of attendance to considerably over one hundred. The work of the society, as shown in the papers and discussions at this meeting, well maintains its grade. The time was about equally divided between practical and theoretical matters, the latter being naturally in direct relation to general physical chemistry. There appears to be a steady increase in the importance of the society. Its membership has grown to over 600, of which the attendance constituted a very good percentage. Nor is there any danger of financial difficulties, for the treasury contains a very substantial balance.

A commendable feature of the meeting is that with but three sessions, one on the morning of each day, the full amount of work laid out in advance was disposed of, and that without any restriction of discussion. This allowed the afternoons to be utilized for visits to the technical plants at Niagara Falls and Buffalo, and the evenings for social enjoyment. A successful smoker with musical entertainment, a dance and a trolley trip down the Niagara gorge furnished diversion from the serious work of the meeting.

RESISTANCE FURNACES.

The professional work of the meeting was begun by Mr. F. A. J. Fitzgerald (Niagara Falls, N. Y.) with a paper entitled "Theoretical Considerations in the Construction of Resistance Furnaces." Electric furnaces in which heat is produced by the current passing through resistance, as distinguished from arc furnaces, may have either a fixed charge (intermittent working) or a moving charge (continuous working). The paper divides fixed-charge furnaces into two classes, and describes some furnaces of both classes, as follows:

Resistance furnaces may be divided into two sub-classes —furnaces in which the current passes through the whole charge and those in which the current passes along a definite path or paths, thus localizing the heat. Of the various resistance furnaces that have been developed, those due to Mr. E. G. Acheson present unusual interest, because they cover a considerable range of temperature and involve certain conditions as to accurate temperature regulation.

Graphite Furnace.—In this furnace the highest temperature attainable is desired. The carbonaceous material, anthracite coal, coke, etc., is placed in a trough-like furnace, and through the center of the charge is a series of carbon rods connecting the furnace terminals. Anthracite coal, the raw material usually employed, is practically a non-conductor of electricity, and at first the current passes through the core of carbon rods. The heat generated in the core converts the surrounding coal into graphite, which then becomes a conductor and heats another layer of coal, and so on till the process is complete. This furnace belongs to both sub-classes of the resistance type.

Graphite-Electrode Furnace.—The furnace belongs to the first sub-class, but is peculiar in that the heat is mainly generated outside the articles under treatment. In the most general case the electrodes to be converted into graphite are arranged in piles, and the spaces between the latter filled with granular carbon. Since the resistivity of the granular carbon mass is much greater than that of the electrodes, most of the heat energy will be developed in the former. The advantage of this type of furnace is that it permits of treating a large mass of low-resistance material without using currents of excessive amperage.

Carborundum Furnace.—Carborundum is a substance that is decomposed at the temperature of the graphite furnace, hence in its manufacture careful temperature regulation is necessary. The charge, consisting of sand and coke, in the form of powder, is put in the box-like furnace, and through its center passes a conducting core, which may consist of carbon in a granular form, or of carbon rods, connecting the terminals of the furnace. The current is confined to the core, raising it to a high temperature, and the heat generated is conducted into the surrounding mixture, converting it into carborundum. If the temperature of the furnace is too high, the carborundum is decomposed and the silicon vaporized.

Furnace for Moderately High Temperatures.—This is the latest of Acheson's patents, and is of great interest. In the outer zone of the carborundum furnace, just outside the crystalline silicon carbide, is a thin layer of an amorphous substance, known as "white stuff." It is an intermediate product in the formation of carborundum, and the temperatures between which it is formed and decomposed apparently lie near one another. For this reason its manufacture, or that of like compounds, involves serious difficulties, and it was to overcome these that Acheson invented this furnace. The furnace is of the same general form as that used in the manufacture of carborundum, but it contains several cores, which are "definitely spaced with relation to each other at distances largely determined by the heat conductivity of the charge, the duration of the operation and the superior and inferior temperature limits of the operation."

In all of the furnaces described above there is one common characteristic—the electrical resistance is a variable quantity, and after any furnace is started there are no means of adjusting internal conditions so as to effect regulation in this respect. In general, the resistance of these furnaces is high at the beginning of a run and low at the end; therefore, means of varying the voltage at the furnace terminals must be used. If the furnace resistance at the beginning of a run is R, at the end of the run r, the maximum voltage attainable E, the minimum voltage e and the maximum watts W, then the following equations must hold:

$$R = \frac{E^2}{W}$$

$$r = \frac{e^2}{W}$$

The application of these equations to the various furnaces considered is obvious. The resistance of the furnace may be varied by altering the dimensions of the core or that part of the furnace which acts as an electrical conductor. There are limits to the variations that can be made in this respect on account of other considerations; but the resistivity of a mass of carbon granules varies with the size of the latter, and further variation may be obtained by the judicious choice of different forms of carbon, which themselves have different resistivities. By taking advantage of this, any desirable variations in the resistance of the furnace may be obtained. The case of the electrode furnace is a special one, the adjusting of the resistance being obtained, to a certain extent, by the spacing between the piles of electrodes.

The paper proceeds by giving some rather general equations for the dimensions of the furnace-zone where a given range of temperature exists (in terms of the heat generated in the core) and for the heat lost by external radiation. Some conclusions are drawn as to the conditions to be observed in order to get the largest volume of active zone and the best heat-efficiency. As certain important factors are left unconsidered, however, the theoretical expressions do not apply accurately. Some discussion arose as to whether, in the carborundum furnace, part of the current did not pass through the carborundum zone. Mr. A. H. Cowles (Cleveland, O.) inclined to this view, but some experiments of Prof. C. F. Burgess (Madison, Wis.), showing that carborundum is a very poor conductor compared with carbon, even at high temperatures, would indicate that practically the whole current goes through the carbon core.

ELECTRIC TREATMENT OF MAGNETIC ORES.

A brief note by Mr. M. Ruthenberg (Lockport, N. Y.) gave some further information about the results obtained with his process for treating magnetic ores too fine to be worked in the blast-furnace. The process, which was described by the author at a previous meeting of the society (see Engineering News, Sept. 25, 1902, for an abstract), consists in passing the fine ore through an electric arc situated in a magnetic field. A pair of rolls, between which the arc plays, feeds the ore downward. It is held by the magnetic field until fused or baked together into lumps, when it at once drops out of the field. This agglomerated or fritted ore may be used in the blast-furnace, but a more recent development is direct reduction in a soaking pit into which the fritted ore drops from the rolls. Either carbon monoxide or hydrocarbon gases are passed through the mass of hot ore in the soaking-pit, whereby complete reduction is accomplished. The reduction of the fused magnetite can take place at a low temperature, little higher than the temperature of boiling water, so that the reduction requires no additional heating (the ore fuses between the rolls at about 1,200° C.), and the metal does not have to be melted. The complete process results in the almost perfect elimination of sulphur. The gangue is removed by magnetic concentration before the fritting, whereby most of the phosphorus is removed.

The paper gave the latest and lowest figures obtained for the consumption of electric power in the process of agglomeration; the essential part of the paper is as follows:

The truth of the blast furnace is that it is a highly economical device for accomplishing its end and will continue to be so until methods be found that will perform its functions for less money. However, some classes of ore may now be more cheaply reduced to metal by other means than the blast furnace, making a product whose analysis cannot be produced in the blast furnace at all. Given a magnetic ore carrying gangue, sulphur, and phosphorus in prohibitive quantity for making good steel economically, such ores find no market tributary to the blast furnace. On the other hand such ores may be crushed, magnetically concentrated, electrically smelted and produce the best of steel at a price which can compete with an ideally situated blast furnace.

In last year's paper I made the assertion that "the work of the electric furnace was performed upon a ton of ore with something less than 500 KW.-hours of energy." To-day I am prepared to report to you that I am doing the same, but better work, with one-half the energy.

Three problems have presented themselves for solution, in the conduct of my work; first, the power required to agglomerate and sufficiently heat for subsequent reduction; second, the regulation of the size of the agglomerated particles; and third, the amount of reduction of the agglomerated material. The status of those three problems to-day is that a ton of ore is being agglomerated with an expenditure of about 250 KW.-hours; the size of the product is under perfect control; the reduction is being made absolute. Inasmuch as the only function of the electric current is to agglomerate the dusty particles into coherent masses without binder or flux, and to convey a sufficient quantity of heat to the ore in the soaking pit, to permit the reducing agents to perform their functions, it will be readily comprehended that the heat and current losses due to maintaining a molten mass are lacking.

With electric power at ¼ cent per KW.-hour there is, then, a power charge of 62.5 cents for the electric fritting. Ores that can stand this expense may be thus prepared for the blast-furnace, but the reduction in the soaking pit is preferred. It was not made quite clear in what form the iron is obtained from the reducing pit, nor what its carbon value is.

STRIPPING BRASS FROM IRON BY ELECTROLYSIS.

An interesting application of a special property of iron is made in a process worked out several years ago. A paper read at this meeting by Prof. C. F. Burgess (Madison, Wis), under the title "A Practical Utilization of the Passive State of Iron," contains the first description of the process that has been published, outside of the patent records. The following is a reprint of this description:

In what may be considered the ancient literature of electro-chemistry the fact was pointed out that iron and steel may be made to assume that peculiar condition known as the passive state by employing the material as an anode in suitable electrolytes. Among such solutions are sodium nitrate and various other soluble nitrates. Upon assuming the passive condition, the iron no longer becomes attacked by the anode products, oxygen being liberated, and the metal acting towards the solution as would an anode of platinum. The passive state thus pro-

duced was held to be, and probably is, the same condition which iron assumes when immersed in concentrated nitric acid, the passivity probably being due to the same causes in both instances. Whether this peculiar condition is the result of the formation of a coating of iron oxide or of nitrogen oxide, or of some other material, is a disputed question, a discussion of which is foreign to this paper. While this peculiar behavior of iron, when used as an anode material, has been known for many years, it is only quite recently that it has been made use of in an industrial way.

Some years ago we developed in our laboratory a process for removing brass from steel tubing, the brass having been left on the outside of the tubing as a superfluous material during the brazing process. An improvement in the method of brazing employed extensively in the manufacture of bicycles consisted in dipping bodily a portion of the frame to be brazed into a bath of melted spelter, which was covered by a suitable flux. By this operation not only was the brazing effected within the joints, but a thin layer of brass adhered to the outer walls of the tubing, so that it became necessary to remove this layer in preparing the frames for receiving a coating of enamel. This was effected for some time by filing, a process which had the disadvantage of entailing a large amount of labor and frequently of damaging the thin tubing, as some of the iron was removed as well as the brass. An attempt was made to employ an electrolytic stripping process for removing this brass, but, upon trying a great many electrolytes, it was found that the iron itself tended to corrode much more readily than did the copper which enters into the constitution of the brazing spelter; and the problem resolved itself into finding a solution which would dissolve the copper, but in which the iron would not corrode.

Iron has a position considerably above copper in the electrochemical series of elements, and where two different metals are in contact the natural tendency is for the more electropositive one to go into solution with the greater ease. The idea presented itself of making the iron more electronegative than the copper by causing it to assume the passive state, and upon using the sodium nitrate solution in which this state could be developed it was found that the brass could be completely removed and the iron left intact. This method of electrolytic stripping was installed and operated with success in various factories, and is now an important adjunct to the dip-brazing method. This same electrolytic stripping process may be applied equally well in removing silver, lead, tin and other metals more electronegative than iron from an iron surface. Nickel cannot be removed in this way, however, since nickel, as well as the iron, assumes the electronegative or passive state.

. . . . . .

In removing brass from iron, the current should remove it at the approximate rate of 1 gram per ampere hour, provided that all of the current enters the solution from the brass and none of it utilizes the iron as an anode surface. To determine how nearly this is the case when iron and brass in contact are exposed simultaneously to the solution, a brass and an iron anode, each having dimensions of 1 × 2.75 ins., were immersed in a sodium nitrate solution, and each was connected through an ammeter to the same source of current. It was found that on first closing the circuit almost all of the current passed through the iron anode, but after operating for a few seconds the iron became passive, after which the brass took all of the current. By using very high current densities, however, the iron may begin to conduct a small portion of the current, thus causing a liberation of oxygen on the iron surface.

From these tests it was shown that the current has a high efficiency in the removal of the brass, and a practical trial has demonstrated that a small percentage only is wasted by flowing from the iron surface, provided the solution be maintained in good working condition and the applied electrical pressure be kept within suitable limits.

In order to prove that the iron anode became, not merely a non-conductor, but actually electronegative, the author made a series of experiments on an electrode of iron in various sodium nitrate solutions, by measuring the "single potential" of the electrode both before current was passed through and after different currents had been passed. It was shown that the iron becomes strongly electronegative after appreciable current has begun to flow. In answer to a question the author expressed the opinion that the action is due to formation of a film of iron peroxide, similar to the case of lead; the film on the iron is, however, too fine to be detected.

ELECTROLYTIC COPPER REFINING.

Under the above title Prof. W. D. Bancroft (Ithaca, N. Y.) presented an excellent discussion of the conditions of efficiency which should govern commercial electrolysis of copper in refineries. It appears that among the different refineries the current-density employed and the temperature at which the solution is worked vary greatly. In order to determine how the cost of working varies with temperature and with current-density, an extended series of experiments was conducted at Cornell University. Care having been taken to approximate commercial conditions as closely as possible, the results enabled direct conclusions to be drawn as to proper temperature and most efficient current-density. It is further noted that most refineries use open tanks, which allows a great deal of heat to radiate from the solution, thus increasing the cost of heating. Tests of radiation at various temperatures were made, and the results show that, for economy in heating, closed tanks should always be used.

We need not detail the experiments here, but it may be of interest to reproduce the author's clear statement of the problem, as given in the introductory paragraph, and his conclusions:

In determining the best conditions for the electrolytic refining of copper, we must consider the cost of the power necessary to precipitate a tank-full of copper under different current densities and at different temperatures; the cost of heating the tank; the deterioration of the electrolyte; the interest charge on the copper in the tank; the cost of pumping, and the quality of the copper deposited. Good adherent copper can be obtained at almost any current density, provided the rate of circulation be sufficient. The question of the cost of pumping has not been taken up, and this is supposed to remain constant while the conditions are varied. The watt-hours necessary to precipitate a gram of copper increase with increasing current density, and decrease with rising temperature. The cost of heating increases with rising temperature, and the interest charge of the copper in the tank decreases with increasing current density. With increasing current density, we have to strike a balance between the increasing power and the decreasing interest charge. With rising temperature, we have to strike a balance between the decreasing cost of power and the increasing cost of heating.

. . . . . .

It is evident (from the experiments) that to operate at a temperature of 90° C. and a low current density is entirely out of the question, not only on account of the cost of power to heat the solution and precipitate the copper, but also on account of the deterioration of solution, which takes place very rapidly under these conditions. At this high temperature and the higher current densities, the cost rapidly approaches a minimum, but here also the deterioration probably more than offsets the advantage of reduced cost of power. To operate at 20° C. is not so costly as would seem at first thought. The cost is maximum at the lowest and the highest current densities, reaching a minimum between 2¼ and 2½ amperes per sq. dm.

At 50° C. it would not be economical to operate at 1 ampere per sq. dm., but the cost drops off very rapidly between 1 and 2 amperes. At the higher current densities the cost fluctuates but very little, reaching a minimum at about 2½ amperes per sq. dm.

The results at 70° C. seem the most satisfactory, and it is at this temperature that we shall get the best results. Although the cost runs very high at this temperature for a current density of 1 ampere per sq. dm., it begins to drop off very rapidly as the current density increases, until it assumes a practically constant value at the higher current densities. Between 3.5 and 3.75 amperes per sq. dm. would be the best current density for obtaining economical results, for at this density no extra power would be required to heat the solution. Operating at this current density, and with the tanks covered, the current alone would be sufficient to heat the electrolyte to over 80° C. In order to secure a good circulation, essential for a good deposit with high current densities, the present method of pumping could be retained. If the gutters leading to and from the pump were properly insulated, the solution would not drop below 70° before returning to the tanks. Moreover, running at this high current density, there would be a considerable saving in the first cost of the plant, inasmuch as fewer tanks are needed for the precipitation of a given amount of copper in a given time.

The lower the cost of heating, the greater the advantage of a high temperature. Lowering the rate of interest decreases the advantage of a high current density. With covered tanks, it will be possible for men to work in the tank room even with the electrolyte at 70° C. It has been suggested by various people that covering the tanks would interfere with detecting short-circuits, but this point seems not well taken. If the covers are so arranged that they will swing or lift open easily, the only difference will be the slight extra time necessary to remove the covers.

If we compare the cost of working under so-called standard conditions of open tanks, a current-density of 14 amperes per sq. ft., and a temperature of 50° C. with the cost of working with covered tanks at 70° C. and a current density of 3.5 amperes per sq. dm. (31.5 amperes per sq. ft.), the saving by the latter method will be very close to a dollar a ton of refined copper when all power is figured at $20 per HP.-year.

Therefore, in order to operate a plant most economically, copper should be refined electrolytically under these conditions: (1) Covered tanks; (2) current-density, 3.5 amperes per sq. dm.; (3) temperature, 70° C.

Communicated discussions from Mr. L. Addicks (Great Falls, Mont.) and Mr. B. Magnus (Anaconda, Mont.) indicated that practical refiners have some arguments to present in favor of their present practice. Mr. Magnus claimed that a current-density as high as that advocated would greatly increase the expense of keeping the solution constant, and cited the case of two plants using respectively low and high current-density, the latter with a labor-cost 40% higher than the other. Mr. Addicks stated that the current-density used at Great Falls is so high (40 amp. per sq. ft.) that the copper must be stripped from the cathodes very frequently, so that the labor-cost is very high. The proposal to cover the refining tanks, he thought, would not be readily accepted by refiners, the same idea being also expressed by Mr. Magnus. Difficulties of inspection were urged against the covered tank, though it was admitted that at high solution temperatures covers would be necessary. In reply Prof. Bancroft stated that good adherent copper could be obtained at a current-density of about 30 amp. per sq. ft. without any difficulty. The objection urged against deterioration of the solution at 70° C. did not hold because the experiments showed no greater deterioration than at lower temperatures. Covered tanks should give no extra trouble in inspection. The cost calculations in the paper were all made on the basis of $20 per HP.-year, but the results could readily be modified to suit other prices. He cited the case of a large works in Michigan which produces its power from a cheap grade of coal for $25 per HP.-year

NICKEL-PLATING.

Another paper having close relation to practical electrochemical work was one by Mr. O. W. Brown (Madison, Wis.) on "Efficiency of the Nickel-Plating Tank." The difficulties in nickel-plating are quite different from those met in refining copper by electroplating. It has been found that the nickel solution must be kept very constant in composition and free from impurities in order to give satisfactory plating, while for economy in electric power the polarization of the electrodes should be a minimum. Various tests were made by the author to find out what conditions must be observed to get the best results. Character of electrodes and current-density were the principal variables examined.

From the results of these measurements the fact is shown that satisfactory operation of a nickel-plating solution depends to a large extent on the character of the anode employed. This is a fact which has been recognized by platers as a result of practical operation. It might be a natural supposition that the best results should be expected with the purest anode material, but this apparently is not the case. It appears that the presence of copper is advantageous to a certain extent, and it is quite likely that certain other impurities which are usually present in cast nickel may be equally advantageous. It has been shown that rolled nickel or electrolytic nickel are decidedly unsatisfactory for anode service, and the reason that the cast nickel shows a superiority may be due to the impurities or to a different physical structure, which gives rise to a great porosity and roughness of the surface, and thereby a greater actual surface area.

In electroplating operations the cathode has naturally been the point at which most attention has been given in the production of certain qualities of deposit, but a study of the conditions at the anode is equally important, for if the corrosion at that point is satisfactory the cathode will largely take care of itself. The lack of efficient corrosion at the anode results in an excess of acid being formed, which, diffusing to the cathode, causes a lower efficiency at that point as well. A change of efficiency at the anode is in a very short time made apparent by a similar change at the cathode.

In instructions which have been published from time to time for operating nickel-plating tanks, the voltage which is necessary for plating is referred to in an indefinite way. This is probably due to the fact that the electromotive force required under different conditions is of a considerably different value, so that no definite rules can be laid down. The electroplater can obtain an efficiency of 90% or more if cast anodes are used, with an anode density of about 5 amperes per sq. ft. The best method of obtaining a check on his efficiency is by the determination of

the anode discharge potential. This should not be allowed to reach a greater value than — 0.45 volt.

It is possible, however, that the study of such single potential is too much of a laboratory test, and requires apparatus which is not at his disposal. A study of the total polarization pressure, however, while not being as definite in the indications as a study of the individual electromotive force at the electrodes, will serve as a means for determining whether the cell is operating properly. When the polarization goes much above 0.75 volt, the assumption is justified that the anode is not corroding properly, and on the other hand, if the polarization is below 0.70 volt the efficiency at the anode is as high as can be obtained. The means for measuring this polarization is at the disposal of most electroplaters, the method consisting in connecting a voltmeter to the anode and cathode terminals while current is flowing, and then suddenly interrupting the current and noting the pressure between the electrode immediately after.

It was objected by Mr. W. M. Johnson (Iola, Kan.) that the calomel test electrode and the potentiometer were too expensive and delicate instruments for the nickel plater. Prof. C. F. Burgess (Madison, Wis.), however, claimed the calomel electrode to be well adapted for use by the practical man, while the potentiometer may be home-made at no great cost. Prof. J. W. Richards (So. Bethlehem, Pa.) attributed the beneficial effect of copper in the anode to local action which aided solution of the nickel.

AN ELECTROLYTIC CELL USING ALTERNATING CURRENT.

Mr. C. Hambuechen (Madison, Wis.) described a cell for producing metallic sodium from fused caustic soda by electrolyzing with an alternating current. An aluminum electrode in certain fused salts, among them caustic soda, will readily permit current to flow into it from the electrolyte, but opposes a high resistance to passage of current in the opposite direction. This property has already been utilized by the author in conjunction with Prof. C. F. Burgess in an electrolytic rectifier, for producing direct current from alternating current. It is now found that a similar cell may be used as a combined rectifier and electrolyzing cell. An iron and an aluminum electrode were immersed in fused caustic soda. This salt is decomposed at about 4 volts, while the aluminum retains its peculiar property up to 40 volts pressure. Alternating current being supplied to the cell, the sodium liberated rises to the surface. A perforated aluminum diaphragm surrounding the aluminum electrode prevents diffusion of the products. Some experiments made with this cell show that its efficiency is less than with direct current, but if the latter has to be produced from an alternating supply by a rotary converter, the difference is greatly reduced.

Special importance was claimed for the perforated aluminum diaphragm used in this cell. With alternating current this diaphragm is practically a non-conductor (below the critical voltage) and all the current flows through the small perforations. Since aluminum is not corroded in pure non-aqueous caustic soda, this type of diaphragm may be found valuable, as ordinary diaphragms are not satisfactory for use in fused caustics.

A brief paper presented by Mr. Byrnes (Washington, D. C.), entitled "A Note on Metallic Diaphragms," described another special type of diaphragm which has been developed for use in fused sodium hydroxide, and which is not limited to alternating current. The diaphragm consists of crushed magnetite, which may be mixed with a small quantity of Portland cement and molded in place between perforated iron cups. This diaphragm was first used in 1896; it has a very high ohmic resistance and does not act as a bipolar electrode. It has since been found that certain other materials may be used, such as finely-divided coke or lead.

Two other papers dealing with subjects of direct practical bearing were presented. Mr. P. G. Salom (Philadelphia, Pa.) described very briefly the new revolving electrolytic cell used at the plant of the Electrical Lead Reduction Co., at Niagara Falls, for producing lead from lead sulphide ore (galena). By the use of this cell, with higher current density (decreasing toward the end of the process) the time of reduction for one charge has been reduced from 5 days to 1½ hours. Hydrogen sulphide is produced as a by-product; it is oxidized to 60% sulphuric acid without concentration. The lead is obtained in the spongy form and it is burned to litharge or used for making white-lead. Mr. W. H. Walker (Boston, Mass.) read a paper entitled "Electrometallurgy of Gold." Electrolytic treatment of gold ores may be done by two classes of apparatus. In the first the ore is leached out and the solution is circulated between a series of electrodes; the cyanide solution is split up into metallic potassium and gold cyanide, which latter is split up by a secondary reaction with the potassium so that the gold is finally deposited. The Siemens-Halske process is of this type. It has long been the endeavor to develop a method whereby the ore may be electrolyzed directly. Several forms of apparatus have been developed in which the crushed ore carried by an electrolyzing solution is moved between the electrodes, depositing gold directly. None of these have proved successful in practice, however. A method was recently worked out by the author for treating rebellious ores such as the Cripple Creek tellurides. The apparatus is somewhat similar to those of the second class above described, but the direction of the current is reversed. It was found, however, that on a commercial scale the process did not succeed, due to mechanical difficulties in bringing the ore near to the electrodes while yet not scouring off the deposited metal.

A number of papers discussed purely theoretical questions. In addition the last day's session was largely given up to a general discussion of the dissociation or "ionic" theory.

Mr. I. J. Moltkehansen (Perth Amboy, N. J.) reported "An Experiment on the Electrolytic Determination of the Basicity of Acids." One of the compounds of metaphosphoric acid of disputed composition was investigated by finding its conductivity and comparing the result with that given by Ostwald's law.

Prof. J. W. Richards and Mr. W. S. Landis (So. Bethlehem, Pa.) presented a paper on "The Electrolysis of Water." This was supplementary to a paper read at the last meeting of the society (see Engineering News April, 1903), wherein it was shown that when in a cell of acidified water there is a very high resistance through the electrolyte between the electrodes, a potential many times higher than the "critical" or decomposition voltage may be applied without producing electrolysis. Moreover, the relation between current flowing (measured by an ammeter) and the voltage between electrodes is a straight-line relation corresponding exactly with Kohlrausch's conductivity value for the solution. The present paper records further experiments, which lead to the conclusion that in order to obtain these results, or to use this method for directly measuring the conductivity of a solution, the following conditions must be observed:

I. The current must be kept within the limit of that which can be completely depolarized by the gases in solution in the electrolyte.

II. The electrode surface must be large enough to allow this depolarization to take place simultaneously with the decomposition.

III. The current readings are the maximum values obtained immediately on closing the circuit, the electrodes being free from polarization before connection is made.

Mr. F. A. Lidbury (Niagara Falls, N. Y.), in a paper entitled "On the Supposed Electrolysis of Water Vapor," described experiments which lead him to the conclusion that electrolysis of water vapor is a quite different phenomenon from the electrolysis of water as water. In the former the amount of gas liberated is in general quite different from that liberated in a water voltameter by an equal quantity of electricity, and the separation of the constituent gases is not the same in character.

IONIC DISSOCIATION.

The theory of the dissociation of substances in solution has created a new science, physical chemistry. From simple but broad beginnings the theory has been elaborated to an extreme degree. It has been carried bodily over into the field of gases and some of its auxiliary developments have even been speculatively applied to solids. The importance of the theory lies in the great use that has been made of it to guide physical and chemical research along new lines and to coördinate and systematize observed phenomena. Its assumptions and conclusions are by no means universally accepted, however. The theory does not fit quite all of the observed facts; moreover, since it has been recently taken up as a club to destroy the whole atomic theory renewed attention has been directed to its shortcomings. The discussion of dissociation at this meeting was on the whole a criticism of the theory. It dealt so largely with matters of theoretical physics, however, that it need not be reported in detail in this place.

Mr. E. F. Roeber (New York, N. Y.), in a paper on "Theoretical Properties of Free Ions in Solutions," gave a skeleton outline of the essentials of the dissociation theory. He emphasized the fact that it constitutes merely a working hypothesis, a mechanical analogy, serving, like the water analogy in electricity, to render our grasp of facts more comprehensive. He built up this analogy, electrochemically, on the basis of (1) the actions represented in Faraday's law, and (2) the concentration-changes in the solution at the electrodes; the former gives us a splitting-up of the molecules, the latter defines the constitution of the two ions. This completes the analogy or working model. Thermodynamic reasoning cannot aid in establishing the truth of the hypothesis; when applied to the problem, it always involves distinct physical assumptions beyond the preceding. The theory applies strictly only to infinitely dilute solutions, with others it is imperfect; on account of the analogy between the phenomena of solutions and of gases, the theory has been extended to the latter. The speaker's conclusion was that the theory is a tool not perfect but very useful, wherefore its value should not be depreciated.

Prof. W. D. Bancroft (Ithaca, N. Y.) took this same ground: the theory, resting on a very few assumptions, has been extended so as to answer a great many requirements and questions. No alternative theory has yet been put forward. Investigators are all in two classes; those who are searching for further substantiation, and those who are discovering discrepancies between theory and fact. Many such discrepancies have been found, and it is possible that the theory may some time be overthrown.

Mr. C. J. Reed (Philadelphia, Pa.) attacked one claim of the ionic theory from the standpoint of energy. When a solution is electrolyzed it is held that ions lose their electric charges and are deposited as atoms. In this process electric energy should appear, while in fact energy must be put into the solution. He asked for an explanation of this discrepancy. He also referred to an anomalous experiment described at a previous meeting.

Prof. H. S. Carhart (Ann Arbor, Mich.) considered the theory of dissociation very useful as a working theory, but nothing more. Numerous objections to it have been found which are not yet explained. He believed the theory to be in the course of a historical development, which may result in profoundly modifying it. Incidentally, he claimed that electrolytic dissociation, as the program calls it, is an incorrect term, since electrolysis has nothing to do with the theory of dissociation.

Prof. J. W. Richards (So. Bethlehem, Pa.) discussed the various meanings which have been given to the term "heat of ionization." He strongly asserted that matter in the ionic state must still be in the form of a compound, since the heat of solution is never comparable in magnitude with the heat of formation of a compound. He proposed a conception involving an analogy between ionization and vaporization, which was applied particularly to the case of neutralizing an acid by a base.

Mr. C. J. Reed (Philadelphia, Pa.) presented a paper related to this general subject, under the title "Berthelot's Law Relative to the Electromotive Forces of Cells," in which he proposed a change in the expression of that law, eliminating the assumption that the junction of two electrolytes is the seat of an electromotive force.

The subject was also discussed by a number of others, Prof. H. M. Goodwin (Boston, Mass.), Mr. A. H. Cowles (Cleveland, O.), Mr. F. A. Linbury (Niagara Falls, N. Y.), and others.

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The intricacies of heat treatment of steel and the papers and discussions concerning it which are so rapidly multiplied by the metallurgical savants ordinarily fail to excite the practical sense of railway and structural engineers to any great degree of interest. We, however, publish in another part of this issue two papers on the heat treatment of steel which seem deserving of a better fate because of the prospect which they offer to the engineer of receiving in the future a stronger and more lasting material, and to the manufacturer of obtaining at a low cost results for which he has hitherto sought at the expense of much trouble and money. By most of our readers probably the paper on Sorbitic steel rails will be the one read with most interest and the one which will appeal to them as being of the most immediate practical value. The inferior wearing qualities of steel rails produced at the high temperatures necessitated by the rapid rolling of modern rail mills has for some years been and is yet a vital matter to railway engineers in America. For some years the slogan of these consumers has been—a lower finishing temperature! The rail manufacturers have on their part spent large sums of money to meet this demand without reducing the output of their mills. To what extent they have succeeded in this task we need not consider here. Searching in another direction for the same object, a better wearing rail, some railways have struck upon nickel steel, and are conducting tests of nickel steel rails at large cost. That railways are even considering for rails a material of such cost and one, moreover, whose cost is bound to increase upon any large demand for it because of the limited amount of nickel available for alloying purposes, indicates the pressing nature of the demand for more durable rails. In view of these facts the announcement made by Messrs. Stead and Richards in their interesting paper, that by a very simple heat treatment the life of steel rails can be increased from 25 to 50 per cent. is a most important one. In metallurgical language this increased durability is secured by the substitution of sorbite for a portion of the pearlite in the steel. To bring about this substitution it is only necessary to quench the heads of the rails to a certain temperature and allow the residual heat to temper the steel by the slow cooling of the rail. The process is in plain terms a simple hardening and tempering process. Accepting as a fact that this hardening and tempering process will perform all that is claimed, the question arises whether it can be successfully applied to rails with the rapidity with which they are produced by modern rail mills. Messrs. Stead and Richards state that they have not yet an affirmative answer to this question, although they hope to have one before long. It is in this item of practical manufacture that the new discovery, if we can so call it, is certain, it seems to us, to encounter the greatest obstacle to its useful application in rail making, and engineers will watch with great interest for further communications on this point from the distinguished inventors of the process.

The concrete-steel tie as a practical issue in railway track construction was the principal subject of discussion at a recent meeting of the Western Society of Engineers, and probably most of those present were surprised at the amount of practical attention which has been given to the concrete tie. There are the Kimball ties on the Pere Marquette Ry., the Buhrer ties on the Lake Shore & Michigan Southern Ry., the Hickey ties on the Michigan Central Ry., the Burbank ties on the Hecla Belt Line Ry., and the Harrell ties on the Pennsylvania Lines. It is true that only a few of each of these ties are in service, probably not over 300 in all, but they appear to indicate a tendency towards this new application of concrete-steel construction. In addition to these, two or three other railways intend to try the Buhrer tie, the engineering department of the Pennsylvania Lines is investigating the concrete tie question, and the Chicago, Burlington & Quincy Ry. is about to make experiments with a form of concrete tie designed by its own engineers. Two reasons for this activity are, first, the wide range of applicability of concrete-steel as a structural material, and, second, the facility with which experiments may be made. With a steel tie, the inventor has to go to the mills for material, and in most cases the material has to be subjected to shop processes in rolling, pressing, punching, drilling, flanging, etc. For such experiments, therefore, it is a slow and costly process to get the ties made, and any changes that experience might show to be required, might involve costly changes in rolls, etc. The inventor of small means, therefore, has much difficulty in putting his idea to a practical test. But for experimenting with concrete steel ties, a barrel of cement, some sand and gravel (or broken stone), and the necessary steel bars or shapes are readily obtained and at little cost. Any carpenter can make the form, and the manufacture of the tie is extremely simple. Changes in design can easily be introduced by altering or rebuilding the form or mold. Of course the cost per tie is relatively high by such methods, but the experiment calls for the expenditure of only a few dollars and the ties are ready for service. If failure develops or if no railway can be found to take the matter up, there is little loss. But if a railway should undertake to make extensive trials the manufacture of ties in quantity would be a simple proposition. As explained in the review of the railway tie situation in our issue of Sept. 10, this is one of the advantages of the concrete-steel tie, and it appears probable that a considerable development in this use of concrete-steel may be expected, provided, of course, that the results of continued experiments warrant the general introduction of ties of this material.

The above refers only to experience in this country. In Italy, the Adriatic Ry. has been experimenting with concrete-steel ties for about three years, and it was stated during the discussion at the meeting above mentioned that the railways of French China are laid entirely with concrete-steel ties of the Hennebique system, there being now about a million of these in service.

The German engineers are spending a large amount of time and money on experiments whose aim is the production of an electric or steam locomotive which can run 100 miles an hour. According to a cable dispatch, they succeeded last week for the first time in reaching 100 miles an hour speed; but the question which naturally suggests itself to railway engineers in the United States is, who wants to travel at such speeds? Side by side with the speed records of this German experiment, we would set the discussion which took place on the location of distant signals at the recent meeting of the Railway Signaling Club, reported in our last issue. The signal engineer of a leading railroad there stated that he had not been able to work satisfactorily a mechanical signal with a greater length of wire than 2,000 ft.

It is well known that if trains are to be run with safety under the block signal system, the spacing of the distant signal from the home must be proportioned to the speed of the fastest trains. The distant signal tells the engine runner that the home signal stands at danger and that he must stop his train before reaching it, and the faster the train is running, the farther back must this information be given him. With present train speeds it is not uncommon to place the distant signal 2,500 ft. back of the home; and if this is a proper distance for 60-mile-an-hour trains, then for 100 miles an hour the distant signal ought to be placed at least 7,500 ft. back. It must be remembered that the power stored in a railway train varies as the square of its speed, and all this power must be absorbed by the brakes to stop the train. We need not stop to discuss the difficulties in installing distant signals nearly a mile and a-half away from the home signal which controls them, nor the dangers which would be inseparable from the use of such distant signals. Instead, let us give a thought to the task set for the engineer who reads such signals. A hundred miles an hour is 147 ft. per second. Grant that an engineer can read the signal all right in clear weather when he is within 1,000 ft. of it. Then he has 1,000 ÷ 147 = less than seven seconds in which to verify the reading of the signal. But trains are run a large share of the time when the signal cannot be made out at 1,000 ft., or anything like that distance. They are often run when a semaphore cannot be clearly seen till one is within, say, 200 ft. Under such conditions the engine runner would have just 1½ seconds to decide whether his train were dashing on to safety or destruction.

Numerous other considerations might be cited to show that whether it be practicable or not to attain 100 miles an hour in a burst of speed, it is not practicable on railways carrying a general traffic to run trains at speeds very much in excess of the highest now attained. If trains are to be run at 100 miles per hour, then, it must be on a road built for them alone, from which all other traffic is excluded. Numerous attempts have been made to show that such a railway would be a paying enterprise, but the capitalists have never been convinced. The mere fact that the Germans have attained over 100 miles an hour on their experimental road, therefore, proves nothing as to the practicability of adopting such speeds.

We have several times recently had occasion to comment upon the advisability of using macadam instead of concrete as a base for asphalt, brick or other pavements. For some years the city of Akron, Ohio, has been using what might be called a slag macadam foundation that has proved even more satisfactory than hydraulic cement concrete in point of stability under traffic, aside from being much cheaper.

Mr. John W. Payne, City Civil Engineer of Akron, informs us that there are now about 20 miles of pavement laid on an 8-in. slag base, 2½ miles being block asphalt and the rest brick. To quote Mr. Payne:

> The slag makes a more compact base than any concrete made from hydraulic cement; while the cost only amounts to about 18 to 20 cts. per sq. yd.

The pronounced success of this slag foundation makes particularly interesting the specification

under which it is constructed. The specification is as follows:

Slag ballast is to be composed of furnace slag and sand or gravel to be selected and prepared as herein designated.

Slag must be free from dirt, ashes or refuse matter, and must not have been used in the manufacture of asbestos or mineral wool.

Whenever the slag is not taken from the furnace direct to the car, but from piles, and has been subjected to the action of the weather thereby slacking, leaving lime deposits throughout the mass, such dust of limestone must be separated from the slag and not hauled on to the proposed improvement.

Slag must be broken into uniform sizes throughout the entire improvement. The largest pieces shall be not more than four inches in their greatest dimension.

Upon the completed sub-base (which must be the specified distance below the surface of the finished improvement) slag is to be placed, broken and raked to a uniform and true crown, the entire mass presenting a symmetrical appearance as to size, formation and density. The contractor is to use his judgment as to the height, the surface of the slag is to be left above the required surface of the slag ballast to allow for the compression made by the steam roller, and if the operation of rolling makes the surface of the slag wavy or in holes or fails to compress the slag to the required elevation, the contractor is to fill all low places and pick off all high places, and so repeat this operation until when the slag has been finally rolled, the surface remaining will be of the exact elevation and cross-section required.

After the slag has been rolled and accepted, coarse sand or fine gravel will be spread over the slag (and in no case will sand or gravel be allowed to be dumped in piles on the slag) to a depth of one-half inch, and then thoroughly flushed into the slag by the contractor. After the flushing has been thoroughly done, the city will roll the same and any inequalities detected by the use of the roller must be remedied by the contractor so that when the slag ballast is finished it will be of the required crown, grade and elevation.

The contractor is to protect the curb so that when the slag ballast is being rolled it cannot be displaced and any damage done by the roller to the curb must be repaired by the contractor at his own expense.

Slag ballast will be paid for by the cubic yard as measured in the improvement and no allowance will be made for ballast that may be rolled into the sub-base or for ballast that may be put in to bring sub-base to the proper elevation.

It may be added that the slag is broken up with knapping hammers after it has been delivered on the graded street. The sand or gravel is spread over the broken slag to a depth of ½ to ¾-in., and washed in with a hose; after which it is rolled while wet.

This slag-macadam has proved so eminently fit as a pavement base that we again call attention to the true economy that lies in using well-made macadam for pavement foundations where broken stone or slag are valuable.

It seems strange that any city intelligent enough to meter a large percentage of its water-works services should still cling to a schedule of meter charges that makes it an object to waste water. Only a few weeks ago a newspaper in a thriving New England city asserted that such was the temptation placed before water consumers in that community. The absurdity arises through a so-called sliding schedule of rates under which the unit price for all water consumed diminishes as the consumption increases. Thus: The price per 1,000 gallons might be 10 cts. for a consumption of less than 100,000 gallons a month, 8 cts. per unit for 100,000 to 500,000 gallons, and so on. Obviously, 100,000 gallons would then cost the consumer no more than 80,000, but 99,999 gallons would actually cost him $1.99 more than would 100,000. If there was ever any excuse for such a combination of poor financiering with encouragement of water waste it certainly exists no longer. Probably the blame for such folly cannot be laid to any water-works superintendent of to-day, unless it be for failure to give his board of water commissioners no rest until it so amends the meter schedule that the decrease, if any, in unit prices applies only to the excess over the quantity at the next lowest rates.

One of the most interesting of recent contributions to the art of gold milling and cyaniding is the paper by Mr. C. W. Merrill which appears in this issue. Mr. Merrill gives an itemized statement of the cost of cyaniding at the Homestake mine, the total cost of labor and supplies being only 35 cts. per ton. The Homestake plant now treats 1,450 tons every 24 hours, which in itself is a remarkable output, being unequaled even by the great South African mills. It is also noteworthy that the best published record of cyaniding in South Africa is some 20 cts. per ton higher than the present Homestake cost. Where the cost of cyaniding is low the recovery is often low also, but Mr. Merrill states that for the last six months of 1902, the recovery has averaged nearly 75%, a large part of which is by amalgamation of an ore that is neither porous nor oxidized and with its values finely disseminated. The average value of the material cyanided has been only $1.65 a ton.

The cost of milling the ore is not given in detail as it is for the cyaniding, but it is stated to be 40 cts. per ton in the 200-stamp mills. Since 80% of the pulp must pass a 100-mesh screen it is evident that the duty of each stamp is exceptionally high. Mr. Merrill states that the duty is fully 4 tons per stamp per 24 hours, and attributes the output to the nature of the ore, the large proportion of water used, and the narrow 12-in. mortar. Valuable as are the cost data as given, they would obviously be of wider applicability and of more permanent value were the rates of wages and the prices of materials, etc., given. It is difficult to compare results in South Dakota with results in South Africa, where the units of cost are not given. A few years hence when prices of materials and wage rates shall have changed it will be practically impossible to compare milling and cyaniding costs of the past with those of the then present.

SUGGESTED AMENDMENTS TO THE LAWS GOVERNING THE AWARD OF PUBLIC WORKS CONTRACTS.

The laws governing the award of contracts for public works usually require that the work shall be awarded to "the lowest responsible bidder." It would seem that such a statute would make certain that the lowest bidder shall receive the contract provided he can show that he is possessed of sufficient capital and experience and can furnish bonds to insure the performance of the work. What, however, are the facts? During the busy season of the year, scarcely a week goes by without the chronicling of the award of a public works contract to some one other than the lowest bidder. Then the newspapers state that the firm or individual whose lowest bid has been rejected is "taking steps" to secure an injunction or a mandamus. "Taking steps" is usually the beginning and the end of such efforts; for all parties concerned are well aware that the statute vests a semi-judicial power in the awarding board solely because of the existence of the word "responsible" in the statute. The courts will not interfere with the award of a contract to a higher bidder, unless fraud and collusion can actually be proved. It matters not to the court that the lowest bidder can prove that he is responsible, for the court is not the judge of "responsibility," the law vesting the awarding board with the authority to determine for itself, who of the bidders are and who are not responsible.

In a word, a law that was originally designed to prevent fraud actually leaves the gates wide open to fraud.

Of course, it may be freely admitted that if all parties concerned in the letting of a contract are bent on committing fraud, they may find a way to evade any law, however strict its requirements. Notwithstanding this, it still remains true that salutary laws are a great deterrent to the commission of crime. There are various shades of dishonesty, and there are many men whose consciences would not balk at betraying their trust to let contracts to a favored bidder who would hesitate to deliberately defy the law and incur the risk of its penalties.

Besides this, it should be said that in the great majority of cases the engineer-adviser of an awarding board may be counted on to be on the side of honesty and fair dealing, and it not infrequently happens that honest men may be found among its membership even though the majority be corrupt.

Without claiming, therefore, that men can be made honest by any statute enactment, we submit that any change in the law which will make its evasion more difficult and better carry out the intent of its framers, tends to uphold the hands of honest men, and is well worth the making. What we would propose is that the word "responsible" should be dropped entirely from the statute, or it should be defined in a manner that admits of no discrimination on the part of the awarding board The definition of "responsibility" that suggests itself as being the most practical is one which makes "responsible" any contractor who can furnish the bond of a reputable surety company. Under such a statute the awarding board would no longer be the judge of a contractor's responsibility, but the decision upon that matter would rest with the surety company.

Is the surety company a better judge of a contractor's real responsibility than the ordinary awarding board? We believe it is. A surety company, as its name implies, is an insurance company, and its business practice does not differ materially from that of a life insurance company. The life insurance company sends a physician to determine the state of an applicant's health; the surety company sends its agent to determine an applicant's business standing. The life insurance company demands a sworn affidavit of the past health of the applicant; the surety company often exacts the same sort of an affidavit of the past business record of the applicant. In both cases the chances of being insured at all are small if the applicant is defective; and in both cases the company backs its judgment with its money. It may be contended that "straw surety companies" will be formed to effect evasion of the law, and that the awarding board will find it as difficult to determine the "reliability" of a surety company as the "responsibility" of a contractor. Fortunately, however, the state laws governing insurance companies of all kinds make it exceedingly difficult for unreliable insurance corporations to exist; and with the growth of bonding surety companies in size and in numbers the inspection of their financial standing is sure to become more rather than less rigid. Much can be said against the old and essentially vicious practice of accepting the bonds of individuals who oftentimes incur a great liability without any realization of the risk involved; but it is not this feature of insurance to which we desire to call attention. Surety companies, it is true, sometimes make costly blunders in judging the ability and the responsibility of a contractor, but we believe they blunder far less often than do the boards which award public contracts. Moreover, experience is making surety companies more cautious in looking into contractors' past records and present financial status before consenting to go upon his bond.

Of course, there are many engineers, and especially those that have been in charge of railway and similar work, who will maintain that no surety company can be as good a judge of the real ability and responsibility of a contractor as they themselves are. There is a measure of truth in this argument when it is applied to surety companies of the past, and even to some of those of the present day. The surety company, it will be said, can have no knowledge whether a contractor is likely to do honest work or to put it another way, such first-class work as the engineer wants. Honesty, however, or the reputation for doing good work and living up to the specifications, is an asset that surety companies do take cognizance of; and one that they take particular care to investigate, where the conditions make careful and continuous inspection as the work proceeds impracticable. Then, too, if the engineer in charge of the work were to report instances of dishonesty to the surety company, we think the contractor would feel even more strictly bound to honest work than under present conditions; for scamping the work might lead to his being blacklisted by the surety company.

Indeed, the thought forces itself upon us that if there were compulsory public letting of the work of private corporations engaged in semi-public enterprises as there is of work done by municipal corporations, engineers generally would be relieved of much of the present trouble that arises from attempts at "skinning the work." At any rate, it would seem that surety company insurance would be fully as efficacious in discouraging dishonesty as are the present methods.

Going back to a consideration of the generalization that fraud cannot be wholly prevented by any law, we have an object lesson in the work now in progress in one of our large cities. There the law compelling award to the lowest bidder has been rendered nil by the practice of requiring the bidders to submit their own time limit. Since no

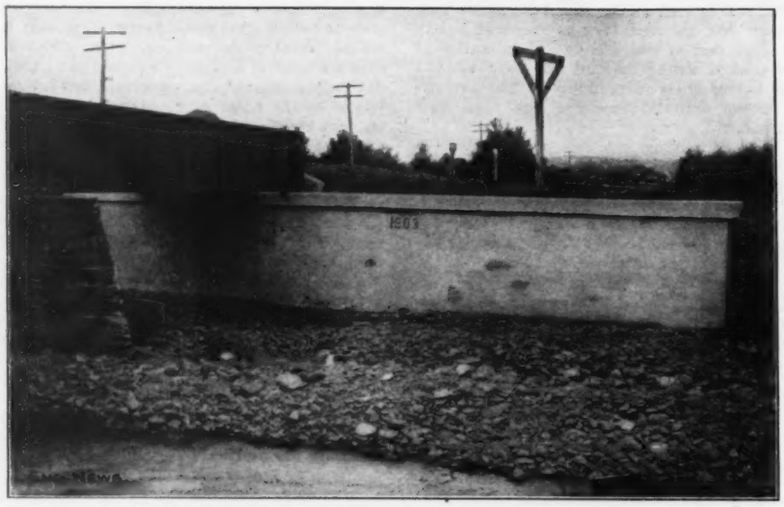


FIG. 1. CONCRETE BRIDGE ABUTMENT WITH DATE PLATE AND LONG WING WALL, ULSTER & DELAWARE R. R., NEW YORK.

definite value is assigned to a day saved in the time of completion of the work, the awarding board is free to assign any value it sees fit; and the board usually sees fit to assign a value that will make the highest bidder the lowest, provided only that his time of completion is lowest. This provision the favorite bidder is careful to comply with, stipulating a date for completion of the work quite beyond the reach of the ordinary contractor. Of course, after the work is under way, the time limit is readily extended without cost to the favored contractor, if we except such private payments as are made for the "courtesy" of time extension.

Here again existing statutes may be so modified as to give at least some measure of protection to the community and to competing contractors. Time limits should be named in the contract, and not in the bidding sheet. The engineer is the man best able to reckon the time reasonably required to complete construction, and he is also best able to give the approximate value of a day saved or a day lost. For these reasons the law should be so amended as to make it obligatory that the time limit, with its penalty and bonus provisions, be made a part of the specifications of public works contracts.

A law so drawn as to require the insurance of a surety company and the estimate of the engineer as to the number of units to be required under every item, including the number of days allowed for completing the work, will go a long way toward securing that fairness in the award of public works contracts which existing laws aim to secure but frequently do not.

LETTERS TO THE EDITOR.

Two Handy Rules in Designing Beam Work.

Sir: The two rules described below should prove valuable time-savers to structural engineers in designing beam work. The first rule is for use in the calculation of girders carrying regularly-spaced floor beams, while the other is a rule for the spacing of beams whose span is such that the safe load is determined by the permissible deflection. Both the rules given are believed to be new.

GIRDERS WITH REGULARLY-SPACED BEAMS.—Girders with a number of equal loads arranged in n equal spaces covering the whole span.

When n is odd: From the distributed load, calculated for the whole span at the weight per foot, *subtract* the $\frac{1}{n^2}$ part, for usual spacing; but if "straddled" (the span beginning and ending with a half space), *add* the same quantity instead of subtracting. The two half spaces count one space in counting n.

When n is even: the load is figured as simply distributed, for both kinds of spacing.

The above rules are exact, and may be applied either to the load itself or to its moment. (That is, for the purpose of calculating the bending moment in the girder. They do not apply to the calculation of end shear.—Ed.)

SPACING FLOOR BEAMS BY DEFLECTION.—In spacing tables of floor beams, as given in hand-books, the spacing is given for strength only, and beyond the "limit span" L_1 the spacing must be reduced so as not to exceed the standard allowed deflection.

Rule: S_1 being the spacing at the span L_1, *subtract* the constant $\frac{1}{7} S_1$ from each space given, between $1\frac{1}{4} L_1$ and $2 L_1$, tapering off from the former to 0 at L_1.

Example from Carnegie's Hand-Book: 6-in. beam at 175 lbs. per sq. ft.

	As given—Span.	As given—Space.	New rule, deduct ft.	Result, space.
$1 L_1$	12 ft.	3.1 ft.	.0 ft.	3.1 ft.
	13 "	2.6 "	.1 "	2.5 "
	14 "	2.3 "	.3 "	2.0 "
$1\frac{1}{4} L_1$	15 "	2.0 "	.4 " $= \frac{1}{7} \times 3.1$	1.6 "
	16 "	1.7 "	.4 "	1.3 "
	17 "	1.5 "	.4 "	1.1 "
$2 L_1$	24 "	0.8 "	.4 "	0.4 "

Similarly for all the tables. The constant $\frac{1}{7} S_1$ should be written in each table at $1\frac{1}{4}$ the limit span L_1 which is 24 times the depth, for the standard deflection, both in inches.

The above rule is approximate, the following being the true figures:

n =	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.0
d =	.0	.07	.12	.14	.14	.15	.14	.12½
	.0	1/14	1/8	1/7	1/7	1/7	1/7	1/8

Here n is actual span divided by limit span L_1, while d is the amount to be subtracted from the spacing given in the hand-books. The upper value for d is nearly the exact value $d = \frac{1}{n^2} - \frac{1}{n^3}$, while the lower figure is the approximately equivalent common fraction.

The limiting span L_1 is found as follows:

Let l = span in inches; d = depth in inches;

f = maximum fiber stress; E = modulus of elasticity.

Then, for the standard limiting deflection $\frac{1}{360}$ of the span,

$$\frac{l}{360} = \frac{2 f l^2}{9.6 E d}$$

or for steel, with f = 16,000 and E = 29,000,000,

$$\frac{l}{d} = \frac{9.6 \times 29{,}000{,}000}{720 \times 16{,}000} = 24.2,$$

while for wood, with f = 1,200 and E = 1,200,000,

$$\frac{l}{d} = \frac{9.6 \times 1{,}200{,}000}{720 \times 1{,}200} = 13.3.$$

For any rate of deflection other than $\frac{1}{360}$ the limit span changes inversely as the denominator of the fraction.

Instead of spacing for a given load per square foot, the safe load per lineal foot of beam may be used and reduced in the same manner.

C. E. Young.

1517 Rhode Island Ave., Washington, D. C.,
Sept. 8, 1903.

Concrete Abutment and Parapet Wall for a Skew Bridge, Ulster and Delaware R. R.

Sir: The accompanying photograph shows a concrete bridge abutment with an extra long wing wall required because of the mountain torrents resulting from the heavy rainfalls in this section of the country through which the Ulster & Delaware R. R. passes and with which this road has continually to contend. This is not the only abutment that has met a watery grave by being carried away in time of high water. There are others. The particular thing about the construction of this abutment is its date and incidentally the parapet wall. It is surprising how so small an addition as the figures "1903" will set off and add to the appearance of this kind of work. The date panel is 18 × 36 ins. × ½-in. deep and is set into the facing of the abutment. The figures are also set in beyond the panel. Both panel and figures were made of wood and fastened onto the inside of the form before the concrete was put in. The figures are 10 ins. high by 1 in. deep.

The parapet wall, Fig. 2, but a trifle over 2 ft. in height, is reinforced with seven short pieces of steel rail studded throughout the entire length of the parapet wall by being set half way down into the main abutment below the bridge seat and half way up into parapet wall, as shown by the drawing. This gives the parapet wall extra backbone, so to speak, and makes it next to impossible for it to become loose from the bridge seat, or for the frost to heave or crowd it forward. The proportions used in the concrete of the main abutment are 1:3:6, in the foundation 1:4:7½, in the coping and bridge seat 1:2:4, in the parapet wall 1:1:2, and those of the mortar facing are 1:2. Portland cement and 1½-in. crushed limestone were used and were mixed in 1 cu. yd. batches by means of a cubical box mixer turned by power. The materials were so thoroughly mixed that it did not seem possible to have them mixed more thoroughly. By means of this mixer we were able to mix and place over three times as much concrete as we have heretofore done by hand with the same gang of men. The foundation is built on piles.

Yours truly, M. H. McGee,
Asst. Engr., Ulster & Delaware R. R.

Rondout, N. Y., Sept. 7, 1903.

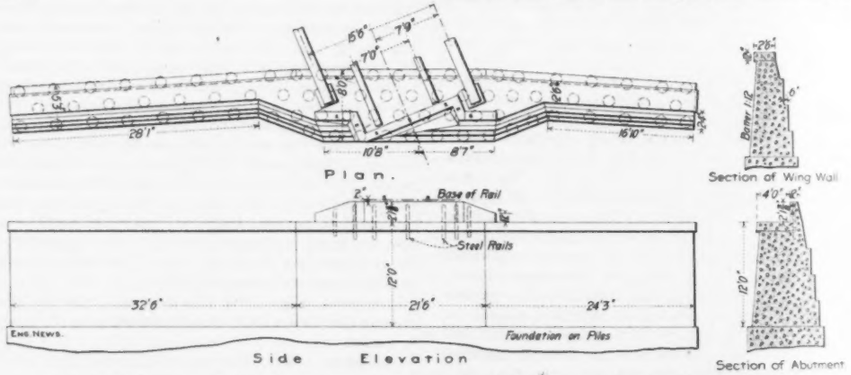


FIG. 2. DETAILS OF CONCRETE ABUTMENT AND PARAPET WALL FOR SKEW BRIDGE, ULSTER & DELAWARE R. R.

THE PARTIAL FAILURE OF A CONCRETE PAVEMENT BETWEEN CAR TRACKS IN NEW ORLEANS.

Replying to a correspondent who wished to know whether or not any concrete pavements had been laid in the United States or not, we stated, in our issue of Aug. 27, that no record could be found of a street paved with concrete. Another correspondent cited a street in New Orleans as an example of the successful use of concrete paving. In reply to a query as to the facts, Mr. W. J. Hardee, City Engineer of New Orleans, has sent us the following letter and a copy of his official report to the City Council on the matter of the concrete pavement in question:

Sir: If the pavement to which you refer to is for roadway purposes, no such pavement has been laid in this city and you have been misinformed. An artificial stone

pavement, however, was laid on the neutral ground of Canal St., the most prominent thoroughfare of this city, a little more than two years ago. As information concerning this pavement may be of interest to you, I submit the following data:

The Neutral Ground in question is 60 ft. wide, and extends from Liberty St. to Delta St., a distance of 4,076 ft.; on it there are five car tracks spaced 9 ft. 6 ins. apart. The tracks nearest the outer sides of the neutral ground have an established grade .15-ft. higher than the Neutral Ground curb; the other tracks are in turn .15-ft. higher, making the middle track .45-ft. higher than the Neutral Ground curbs and the surface of the pavement a compound arch.

The pavement consists of a 4-in. concrete foundation formed of one part Atlas cement, three parts sand, and seven parts washed river gravel; the top course consists of mortar 1-in. thick, formed of one part Hemmoor and one part sand. Under each rail between the ties, in order to minimize the effect of vibration, an inverted pyramid of concrete was placed measuring 3 ft. across the top and 8 ins. across the bottom, the elevation of the bottom being equal to the bottom of the cross ties.

A considerable portion of the pavement has failed, but a large percentage of it is in as good condition as when laid. The appended copy of a letter recently addressed by me to the City Council relative to the above referred to pavement, is self-explanatory and will furnish such additional information as I believe necessary to convey to you a comprehensive knowledge of the entire subject.

Very respectfully, W. J. Hardee, City Engineer.

New Orleans, La., Sept. 11, 1900.

LETTER TO THE CITY COUNCIL, CITY OF NEW ORLEANS.

Gentlemen: Referring to the motion of the Honorable C. J. O'Connor, adopted by your honorable body on Nov. 11, 1902, I beg to inform you that it is not possible for this department to state to what extent the street car tracks have subsided on the neutral ground of Canal St., from Delta St. to Liberty St., for the reason that no record was kept of the exact elevation to which each of the several tracks was constructed.

A grade for each track was established, but as it was difficult and not necessary to comply precisely with the established grades, the tracks were deemed satisfactorily completed when the finished elevation did not vary more than from one-half an inch below to one-half an inch above the intended elevation. As each track in each block was reconstructed and tendered by the railroad company for acceptance, it was tested, and if found not to vary more than above stated, it was accepted, but no record was kept of the precise elevation at which it then was. It is, therefore, impossible to now determine what the precise difference is between the present elevation of a track and the elevation to which it was constructed. A comparison, however, of the present elevation of the tracks and the lowest elevation of the tracks at which they would have been accepted discloses that in places they have subsided as much as 2 ins. The maximum subsidence has occurred where it should logically have occurred, viz.: where the extent and character of the work of reconstruction was greatest, by which is meant where a new gravel foundation was placed and new cross ties and new steel rails employed. Subsidence was due to the compacting of the gravel foundation and bedding of the cross ties in it brought about subsequently by the weight and vibration of the cars moving over the tracks.

Artificial stone pavement of the kind laid on the neutral ground of Canal St. is by virtue of its very composition extremely brittle, and possessing little or no elasticity, is easily susceptible to breakage by influences so powerful as the movement of objects in contact with it, such as the cross ties and rails of the car tracks. Further, vibration occasioned by cars moving over the tracks would readily and rapidly cause fractures, that had been produced by a subsidence of the car tracks, to extend, and, as the tracks are in close proximity to each other, fractures would soon converge and involve extended areas.

I am of the opinion that some of the pavement on the neutral ground of Canal St. has been destroyed by subsidence of the car tracks, but to what extent in area I am unable to even approximately ascertain, because, as has been stated, it is not possible to determine to what extent the car tracks have subsided.

It is certain that all the pavement that has failed is not attributable to subsidence of the car tracks. Some of the pavement has failed because the top course never thoroughly bonded with the concrete foundation and the top course being subjected to greater contraction and expansion due to exposure in a greater degree to the influences of the weather, separated from the concrete foundation and being extremely brittle easily fractured and has disintegrated. This seeming faulty construction could not have well been avoided since it was due to causes beyond the control of the contractor.

The usual and best practice in constructing artificial stone pavement is, first, to lay the concrete foundation, and then before the same has "set up" to add the top course; if the concrete foundation has set up, while its surface may afterwards be thoroughly grouted and in the majority of instances a good bond between it and the top course effected, it sometimes occurs that a perfect monolith will not be formed and the top course will soon disintegrate.

On Canal St. some areas of concrete foundation were laid and rains then occurring and continuing interposed the lapse of two or more days before the top course could be added. Over some of these areas a good bond was effected, and the pavement to-day is in good condition; over other areas it is manifest that a good bond was not effected because the top course has withdrawn from the concrete foundation and has disintegrated. Very respectfully, your obedient servant,

W. J. Hardee, City Engineer.

New Orleans, La., Dec. 23, 1902.

METALLURGICAL TREATMENT OF ORE BY THE HOMESTAKE MINING CO.*

By C. W. Merrill, M. Am. Inst. Min. Eng.†

The Homestake Mining Co. has acquired through consolidation the ground and equipment of the companies at and near Lead, So. Dak., in the northern portion of the Black Hills. The company owns or controls 250 claims, comprising 2,616 acres, and covering about 8,000 ft. along the strike of the lode. At the surface there are several veins, of which three have united in depth, where the main vein ranges from 300 to 500 ft. in width. The 1,100-ft. level is the lowest at present. The rock of both walls is, so far as known at present, carboniferous slate, and the country is penetrated by a system of porphyry-dikes, and in some places capped with porphyry. The output of the company up to January, 1903, has been approximately, $70,000,000.

THE ORE.

The oxidized, open-cut ore is nearly all treated in the three mills on the northern part of the property, which are as follows: The Mineral Point (formerly the De Smet), of 100 stamps; the Monroe (formerly Caledonia), of 100 stamps; and the Pocahontas (formerly the Deadwood-Terra), of 160 stamps. The cyanide-plant, to treat the leachable portion of the tailings from these North End mills, has recently been installed and put into operation at Gayville, or Blacktail, as it is now known.

The Homestake lower-level ore, which comprises the greater part of that being milled at Lead, may be described as a hornblende, garnetiferous schist or slate, which has been crushed and infiltrated with free silica and pyrites, the latter being about 7 or 8% of the ore, and comprising pyrite, pyrrhotite and traces only of chalcopyrite and arsenopyrite.‡

MILLING.

The ore receives its first crushing in rotary breakers at the hoists, and this product varies in size from that of sea sand up to rock having an extreme dimension of 4 ins. From bins at the hoists at Lead, the broken ore is trammed to the three mills; the Homestake and Golden Star, containing 200 stamps each; and the Amicus (formerly the Highland), in which there are 140 heads, making a total of 540.

From the mill bins the ore passes to the mortar, which is of the now celebrated Homestake narrow pattern, where it is crushed between cast-iron shoes and dies, the weight of the stamp when equipped with new iron being 900 lbs., the drop 10½ ins. and falling 88 times per minute. The screen is of the steel-needle slot type No. 8, and the bottom of the screen opening averages 10 ins. above the top of the dies.

The long drop, high discharge and small area of screen openings produce an extremely fine pulp, about 80% passing a 100-mesh screen, and it is to the writer a most remarkable fact that under these conditions such a high stamp duty is maintained, it being fully 4 tons per stamp per 24 hours. This duty is possible only because of: 1, the very favorable nature of the ore, the slate and pyrite crushing readily and the quartz being an excellent medium of attrition; 2, the large proportion of water used, being from eight to ten times the weight of ore crushed; and, 3, the narrow mortar, which is only 12 ins. wide at the lip.

This very fine and thin pulp is in the most excellent condition for amalgamating, which process is conducted both inside the mortar and outside, on full-size ⅛-in. plates in series (each 54 × 144 ins.) to each mortar. The first of these is a copper plate, and the other three are silver-plated copper, the weight of plating being 2 oz. per sq. ft., and all silver plating being done at the works. The addition of the three silver plates to each stamp battery by Mr. Grier has proved one of the most valuable steps in the treatment of this ore, and has brought about an additional profit amounting to, approximately, $250,000 during the year 1902, over and above what would have been realized from amalgamation had the outside plate surface been only that of the one copper plate—which, by the way, is considered ample in many of the large modern plants of the day.

In connection with amalgamation, the practice at the Homestake conforms, as far as conditions will permit, to the theory that the maximum results are obtained when the temperature of the water used in the batteries is low enough to exert the minimum influence on the minerals of the ore; and it is contended that the plate yield proves the correctness of this theory.

It would be interesting to investigate the question of amalgamation and finer crushing in other gold-producing sections, particularly in South Africa, where the yield from this source is reported to be from 55 to 60%, as compared with 70 to 75% at the Homestake. Perhaps, finer crushing would not only greatly increase their amalgam yield, but also reduce the values lost in their cyanide residues. This seems specially likely for that country, because their slimes have been proved to have value sufficient for secondary treatment, whereas this has not yet been proved at the Homestake, where the advisability of sliming such a large proportion of the ore has been a debatable point, because the slimes here contain only 85 to 110 cts. in value per ton. But of this more will be said later. The total cost of milling in the 200-stamp mills at Lead is, approximately, 40 cts. per ton.

CLASSIFICATION.

We now have a pulp containing eight or ten parts of water to one of ore, and much of the latter is infinitesimally fine. The tailings as they leave the mill are sized, with the following result: Coarse (remaining on 100-mesh), 22%; middles (between 100 and 200-mesh), 18%; fines (passing a 200-mesh screen), 60%. That is 60% of the particles issuing from the mortar have less than 0.0001 sq. in. of cross section.

When the erection of the cyanide plant had been determined upon, the question of a tailings wheel to elevate the pulp and permit the location of the plant nearer the mills being under discussion, it was calculated that to elevate the tailings at a cost of about 2 cts. per ton would cost the company, approximately, $140,000, on the proportion of the material then blocked out in the mine which would be available for leaching. In other words, for every cent per ton which could be saved in the secondary treatment of the leachable material, the company would profit ultimately to the extent of at least $70,000. Consequently, the plant was located, as shown in Fig. 1, about a quarter of a mile below the lead mills; and the problems of transportation and of such classification as would permit the pumping-plant to return its former percentage of water to the mills, presented themselves.

The latter has been met by the installation of the upper cone-house, where 12 gravity-settling cones, 7 ft. diameter and with 50° sides, throw off about half the water, and, perhaps, one-fifth the solid matter, which latter is the very finest slime of the following sizing, during 1902: Coarse, 0; Middles, 1.76; Fines, 98.24%. The thickened slimes are, subsequently, settled out of this pulp, and a part of the water is returned to the mills.

From the bottom of the cones is drawn the thickened pulp, containing all of the leachable material and some of the slimes. This portion is transported by means of a 12-in. cast-iron flanged pipe on a minimum grade of 2.5% and with as few turns as possible, to the cyanide-plant.

The second step in the classification is carried out in the plant proper by means of six more gravity-settling cones, the overflow from which, of a like composition to that of the first 12 cones, is conducted to a collecting tank, whence it is drawn for the purpose of sluicing out the leachable material after its treatment has been completed. The average sizing of this second settling-cone overflow for 1902 was: Coarse, 0; Middle, 1.38%; Fines, 98.62%.

The underflow from the second set of gravity-settling cones, which is now quite thick, passes to 24 sizing or hydraulic classifying cones, which carry a device for discharging the sand and introducing the water, patented by the writer. By its means the admitting of water does not result in currents of varying velocity, which latter always interferes with uniform separation of slimes from granular material. These sizing-cones complete the classification, which has been a difficult problem, first, because of the extreme fineness of the pulp, and, secondly, because the writer was determined to avoid double treatment, which entails a largely increased installation and operating cost, but which is necessary, unless a product be obtained practically free from slime.

The slime-overflow from hydraulic classifiers had the following sizing-average for 1902: Coarse, 0; Middles, 1.46%; Fines, 98.54%. As regards all slimes referred to

*Abstract of paper read at the American Mining Congress, and to be read at the October meeting of the American Institute of Mining Engineers. Reprinted in advance through the courtesy of the Council of the American Institute of Mining Engineers.

† Lead, So. Dak.: Also Mem. Inst. Mining & Metallurgy, London, England; Associate, Chemical & Metallurgical Society of South Africa.

‡The standards used in this discussion are: The U. S. gold dollar; the U. S. short ton of 2,000 lbs. avoird., and the value of an ounce of fine gold, $20.67. Percentages are given by weight, and not by volume. Sizings are classed as coarse (that portion of the sample which will remain on a 100-mesh screen; diameter of wire, 0.00433 in.; size of opening, 0.00575 sq. in.); middles (the material finer than the opening of the above 100-mesh screen, and coarser than the opening of the commercial 200-mesh screen as given below); and fines (the material which will pass such a 200-mesh screen; diameter of wire, 0.00216 in.; size of opening, 0.00312 sq. in.). A further subdivision of fines is also mentioned, which is based upon the granular, or angular, condition of one portion and the flocculent or amorphous, condition of the remaining portion of these fines.

they will practically pass the 200-mesh screen, the middles being largely wood-pulp.

There is little doubt but that the importance of the most perfect classification possible will be recognized shortly as a vital consideration in the cyaniding of wet, crushed ore; the metalallurgists will not follow the old German practice of "spitzkasten" and "spitzlutten," which are very imperfect machines as compared with a cone-classifier or sizer for separating granular from flocculent material. The writer's judgment is that a scientific classification-system, by which all the granular or

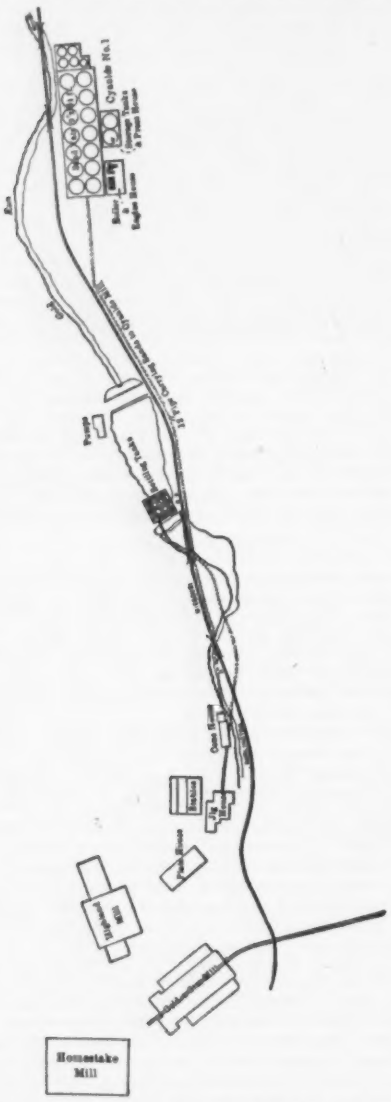


Fig. 1. General Plan, Showing Location of Homestake Cyanide Plant and Other Buildings.

angular material may go to the leaching-vats, and all the amorphous portion to the slime-plant, will in the future be a feature in designing a plant on which the greatest care and experimentation will be put, and the highest grade of technical skill utilized.

CYANIDE-TREATMENT.

By these three steps in the classification we have separated the pulp into non-leachable slimes, comprising about 40% of the ore crushed, all of which will pass a 200-mesh screen and a direct-leachable product, amounting to, approximately, 60% of the tailings, which, although very clean and free from mud, is still of a very fine texture,—as the following sizing-test, the average for the year 1902, will show:

Coarse, remaining on 100-mesh, 40.5%;
Middles, 100 to 200-mesh, 30.8%;
Fines, passing 200-mesh, 28.7%.

While the fineness is notable as the proportion of lower-level ore increases, we can treat an even finer product. A recent charge containing as high as 40% fines, which maintained our normal leaching-rate of 3 to 4 ins. per hour throughout the treatment. This is undoubtedly due to the fact that the fines from the lower-level rock contain a greater proportion of angular or granular material and a less proportion of amorphous, hydrated or flocculent.

The leachable pulp, which contains 10 to 12% of pyrite, is now ready to go to the vats; and on the way lime is added in quantities varying from 3 to 5 lbs. per ton. At first we tried adding this lime in the mills, as is done in Africa, but found that the amalgamation was most seriously affected thereby. Not only was the plate completely coated, weeks being required to get it back in proper shape, but the tailings-values were largely augmented. This result only emphasizes the fact that the process must fit the ore, and that attempts to make an ore fit a process are useless. This practice of adding lime to the battery is, according to the writer's information, unanimously pronounced to work the best results in Africa, and to reduce the values in the slimes lost from amalgamation to half of what they are when no lime is used in the battery.

In our case, however, we have demonstrated that the best results follow from crushing the lime wet into a running pulp which joins that from the sizing-cones, whereby there is less slacking and less loss of flocculent lime in the vat overflow, i. e., in the water which overflows the vat, the sand having settled out. Not only is it of distinct advantage to have our lime go into the tank in unslacked granules, but recent investigations are proving that the average size of these granules has an important bearing on the subsequent cyanide-decomposition and gold-extraction. This seems to be due to the fact that a low alkalinity, but one approximately constant throughout the leaching, is an important desideratum with the Homestake ore, on account of its considerable content of easily-decomposed sulphides. We are not, as yet, prepared to say what is the very best mesh-screen to use on our lime stamp-battery, but at present we are using a wire-screen, the opening of which is $^{11}/_{64}$ sq. in. In this connection it should be said that only the purest lime should be used, the magnesia in the ordinary domestic limestone being objectionable for several reasons.

The classified pulp and the lime having commingled, the mixture passes to the distributor, which is of the garden-sprinkler or Butters and Mein type. Of these distributors there are two, one for each row of vats, hung from a carriage, which travels on a track, and the step of which rests on the top of the center-bottom discharge-gate of each vat, when the distributor is in operation. There are 14 vats, each 44 ft. diameter, 9 ft. deep inside and holding 610 tons of sand. To fill one of these requires from 11 to 11½ hours, which, with our equipment, permits of about five days' contact with solution, before it is necessary to recharge the vat. After filling, the drain-valve is opened, the top leveled, and the stronger of the two stock-solutions, of a strength of 0.14% KCN, is run on. The contact with this solution, including frequent drainages for the purpose of drawing in air, is maintained for about three days.

The air-contact is very important in Homestake ores, owing to the presence of pyrrhotite or subsulphide of iron, which absorbs oxygen with great avidity, and which would greatly retard the dissolving action of the cyanide-solution were not large quantities of the essential oxygen introduced. The effluent solution during this period, having normally a strength of 0.10% of cyanide, is run to the two weak precipitation tanks, 26 ft. diameter by 19 ft. deep, and holding 300 tons of solution.

After the three days contact with strong solution, the weak solution, normally of a strength of 0.10% KCN, is brought into the charge, and this contact is maintained for the remaining two days. The effluent solution from the charge during this period is run to the strong precipitation or rather collecting-tanks, which are of the same size and number as the weak precipitation-tanks. Fig. 2 shows the interior arrangement of the works.

After contact with the weak solution has been completed, wash-water is brought into the charge, and the washing continued until the effluent solution is down to 0.03 or 0.02% in KCN and from 5 to 7 cts. per ton in value.

The charge is now ready for sluicing, which operation is accomplished by two men, with 3-in. hose, in about four hours, using the slime-water from the overflow of the second settling-cones. The center-gate and four side gates afford ample facilities for the discharging. The last foot or so of the sand is sluiced with clear water under 75 lbs. pressure through 1½-in. hose; and the 8-oz. duck filter, under which is another of cocoa matting, is washed clean. The vat is then filled with water, and is ready for the next charging.

PRECIPITATION.—As stated above, the effluent solution resulting from the leaching with strong solution is run to the weak precipitation-tanks, and has a value of approximately, $2 per ton and a strength of 0.10% KCN. When one of these weak precipitation-tanks is full the stream is turned to the other, and the former is then ready for precipitation. It contains 300 tons of solution, which is brought into agitation by means of compressed air, and about 60 lbs. of zinc powder, in the form of an emulsion, is sprayed in during the agitation. The pump, which is of the compound, duplex, outside packed, plunger-type, is then started, and the mixture pumped through two large filter presses 36 ins. square of the flush plate and distance-frame pattern, containing 24 frames, each 4 ins. in depth.

While the gold, silver and excess of zinc remain in the frame and on the cloth, the barren solution passes through the cloth and on to the weak solution storage tank below (of the same size as the sand-vats), whence it passes again to the sand as weak solution. Its value has been reduced by this operation from $2 to 5 or 10 cts. per ton, being a precipitation of 95 to 97.5%. The efficiency of this method lies largely in the fact that the cloths of the presses are coated with about ⅛-in. of powdered zinc and precipitate, so that every particle of solution, having passed through the cloths, gets a molecular contact with the fine zinc, which is true of no other precipitation process. The presses are run without opening for a month, at the end of which period the press gages indicate about 10 lbs. pressure, notwithstanding the fact that they then contain about a ton of precipitate worth, say, $50,000, when they are cleaned up by two men in about six hours, including the putting together with new cloths. Figures covering the labor of cleaning up $50,000 from zinc boxes and from electrolytic precipitation would form an interesting comparison.

The effluent solution resulting from the contact of the tailings with weak solution during the latter part of the leaching is run to the strong-solution collecting-vats. When these are filled, they are strengthened to 0.14% KCN and pumped directly, without precipitation, to the strong solution storage tank, of the same capacity as the weak storage, whence it goes on to the early treatment of the charge, as before mentioned. Its value is from 30 to 50 cts. per ton. It will thus be seen that the strong solution of one day becomes the weak solution of the next day, and that the values are all accumulated in the weak precipitation tanks. The strong solution thus has an approximately constant value, that is to say, only half of the total effluent solution is precipitated, the other half being of a constant low value.

REFINING PRECIPITATES.—As the refining of cyanide precipitates is of some importance, owing to the well-recognized losses taking place in the ordinary methods which are from 2 to 6%, a description of the process we use at the Homestake, in which the loss is less than 0.1%, may be of interest.

The precipitate, after removal from the presses, is treated first with dilute hydrochloric acid in a lead-lined mixing-tank, equipped with a mechanical agitator, a hood, and a powerful exhaust-fan. After agitation and settling,

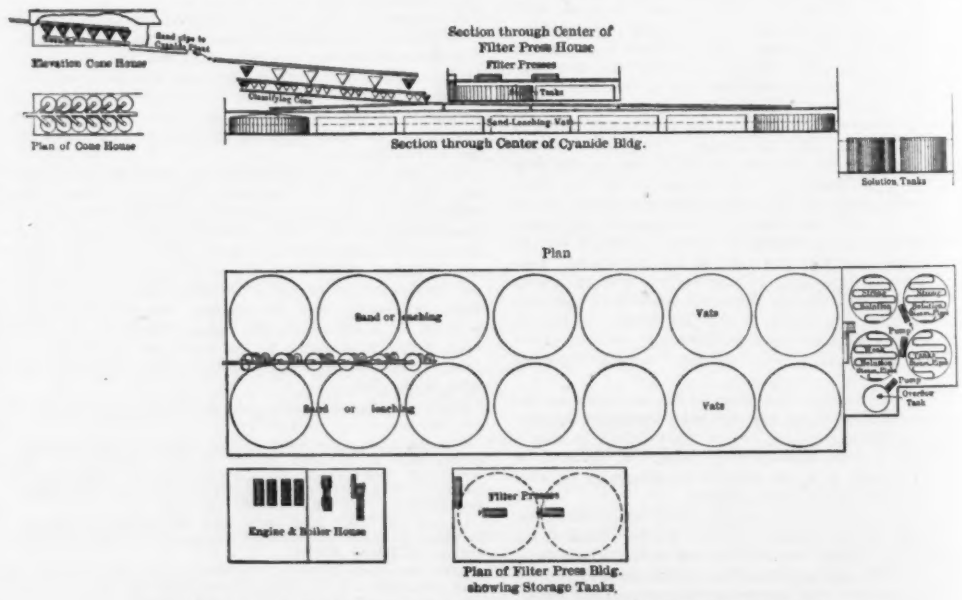


FIG. 2. PLANS AND SECTIONS OF HOMESTAKE CYANIDE WORKS.

the supernatant liquid is forced through a filter-press by air pressure. Sulphuric acid is then added, agitation begun, and the mixture heated. It is then settled, and the supernatant solution put through the press, as in the case of the hydrochloric acid.

Wash-water is then added to the mixing tank and the whole mixture put into the press, where it is further washed. The aggregate value of the acid-liquors and wash-water flowing from the press is less than $20 from $50,000 worth of precipitate. A portion of this value is recovered from a large settling tank, into which the effluent solutions flow, and the remainder constitutes the only loss we have been able to find in this process of refining.

The resultant, acid-treated precipitate is then removed to a large steam-dryer, where a part of the moisture is expelled, but never all, and the precipitate mixed with litharge, borax, silica and powdered-coke. When thoroughly mixed, it is sprinkled with a solution of lead-acetate and the whole mass briquetted under a pressure of 4,000 to 6,000 lbs. per sq. in. The zinc having been removed, and the briquettes having been dried, a borax-slag develops upon the outer surface upon being charged to the cupel, and they fuse quietly, quickly and at a low heat, without dust or volatilization losses. The lead absorbs the values, sinking to the bottom, and slag is tapped off. All of the slag having been removed, the lead is cupelled off as litharge, and the resultant metal, 975 to 985 fine, is ready to run into bars. The cupel-slag and the cupel-bottom are then put through the blast-furnace, the lead-content of the slag reduces to lead, which absorbs the values, and is drawn from the lead-well in the usual manner. This lead is returned to the cupel at the next clean-up, the litharge from the cupellation goes to the next precipitate, and the blast-furnace slag is worth less than $5 per ton.*

The total cost of this refining amounts to less than 0.75%; so that the Homestake Co. realizes $20.52 per oz. for its cyanide-gold, less the usual U. S. Assay Office charges on doré bullion, and the expressage to New York. These charges amount to between 10 and 11 cts.: and the net realization per oz. of fine gold precipitated is thus $20.42 in New York exchange. A parting plant is now contemplated, which will make a further saving in this connection and enable the company to turn out fine gold and fine silver.

TONNAGE, PERCENTAGE AND COSTS.

The maximum monthly tonnage of this plant—which is ascertained by placing cubic-foot boxes in many parts of various vats, determining the dry-weights per cubic foot of sand and averaging a large number of such determinations,—was attained in October, 1902, when 40,236 tons, or 1,298 tons per day, were treated.† This gives to the Homestake Co. the largest sand-treatment cyanide plant in the world; the next largest being, to the best of my knowledge, that of Simmer & Jack in South Africa.

The average percentage recovered in bullion by the treatment for the last six months of 1902 was 74.7%. This is not as high a percentage of bullion as should be recovered from a porous or oxidized ore, or one in which the values are along cleavage-planes; but, in view of the facts that such a high percentage is recovered by amalgamation, that the values are very finely disseminated in the Homestake ore, and that the tailings are very low-grade, we feel, and all our tests so far have verified our conclusions, that it is the economic percentage, yielding the maximum net profit.

Many tests and experimental runs of the plant looking toward a greater net yield have been made, covering longer treatment, stronger and weaker solutions, extra oxidation with sodium and barium dioxide, and other similar reagents, varying alkalinities and alkaline reagents, etc. The question of separate treatment of concentrates and coarse sands has also been investigated, all with negative results. The conclusion of the writer in regard to this latter point is that, even if a higher net yield could be realized by separate treatment, which is contrary to the results of all our tests, a much greater proportion of the fines (passing 200-mesh screen) would have to be thrown off and wasted, entailing a serious net loss.

COSTS.—As to operating costs at the Lead cyanide plant, the following are the averages per ton for the year 1902 during which the average value of the material treated was $1.65 per ton:

Classification—Labor and supplies		$0.017
Treatment:		
Cyanide	$0.152	
Labor	0.030	
Lime	0.022	
Supplies	0.005	
	$0.209	0.209
Precipitation—Labor and supplies		0.026
Power—Labor and supplies		0.051
Water		0.026
Assaying—Labor and supplies		0.013
Refining—Labor and supplies		0.006
Miscellaneous		0.005
Total		$0.353

*The writer has applied for patents covering this process, which was first carried out experimentally during the latter part of the year 1900.

†Since this paper was written, another step in the classifying of the pulp has been added, with the result that this plant is now treating approximately 1,450 tons per 24 hours.

As compared with the above, the lowest costs I have seen authoritatively stated for other plants are as follows:

City & Suburban, South Africa	$0.55
Geldenhuis Estate, South Africa	0.605
Geldenhuis Deep, South Africa	0.62
Robinson, South Africa	0.62
Worcester, South Africa	0.72

The African costs refer, of course, to operations before the late war between England and the South African Republic; but they are the only figures available to me, and I do not think they have been reduced materially since.

As regards the Homestake slimes, which are not at present being treated, their assay-value ranges from 80 cts. to $1.10 per ton, which is very much lower than that of any slimes now being cyanided anywhere, and which does not offer much inducement to undertake their hydro-metallurgical treatment. It is the writer's judgment, however, that a material profit, greater than that attainable by any method of treating the whole bulk of slimes, may be recovered by concentrating these slimes and cyaniding the concentrates so obtained; and experiments on a working scale will shortly be undertaken along these lines.

CONSTRUCTION WORK ON THE PENNSYLVANIA R. R. BETWEEN HARRISBURG AND GALLITZIN.

Fifty millions of dollars for improvements on the Pennsylvania R. R., between Pittsburg and Philadelphia! This is the sum that is to be expended on improvements of a line 354 miles long, and is equivalent to more than $140,000 per mile! To one acquainted with the cost of railway construction it would seem that such an expenditure, even though it includes a large sum for yard construction, is more like an expenditure for an entirely new railroad than for merely improvement of one of the oldest lines in the United States. And as a matter of fact when one comes to view the work itself in progress, it is seen that these so-called improvements are very largely in the nature of entire reconstruction.

It is not our purpose to attempt any description of the numerous changes of line involved in

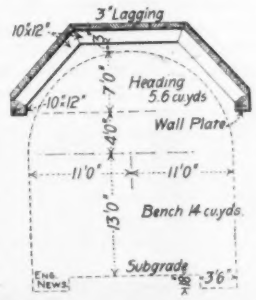


Fig. 1. Showing Dimensions and Timbering of the Gallitzin Tunnel, Pennsylvania R. R.

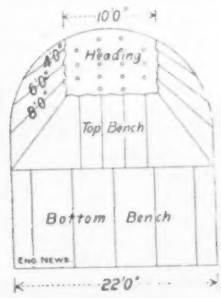


Fig. 6. Showing Location of Drill Holes, Gallitzin Tunnel.

this wholesale re-alinement, for without many large detailed maps showing the old and the new location, any mere descriptions of changes would be profitless. Furthermore, even with such maps, it is questionable whether an engineer unacquainted with the traffic of the road could draw any useful inferences from the changes projected. Hence we shall confine ourselves to the work actually in progress, to the methods employed, and to certain details of construction and of cost. In doing so, however, we shall endeavor to present facts that will be of value to the engineer as well as to the contractor.

USE OF THE NEW ERA GRADER.

Near Marietta, about twenty miles east of Harrisburg, a new railway line is being built down the center of the old Pennsylvania Canal. Material is excavated from shallow pits parallel with the old canal, and hauled into the canal prism where it is dumped. The distance from the center line of the old canal to the center line of the borrow pits is less than 100 ft., and the material excavated is an easily plowed loamy soil, free from stones or roots. Here the contractor has four New Era Graders, two of which were at work at the time a member of our editorial staff visited the work. Each grader is hauled by a 25-HP. traction engine, made by the Case Threshing Machine Co., of Racine, Wis., and the grader loads into Columbian dump wagons, drawn by two-horse teams. The crew and assumed rate of wages are as follows for each grader:

1 engineman on traction engine	$3.00
2 men operating grader at $2.50	5.00
1 team on water tank	3.50
9 teams on 9 dump wagons, at $3.50	31.50
4 men spreading, at $1.50	6.00
1 water boy	.50
1 boy tallying loads	.50
½ foreman, at $4	2.00
Total crew wages per 10 hrs.	$52.00
Coal and oil	3.00
Total	$55.00

Careful timing showed that the grader traveled 40 ft. in 15 secs., in which distance a wagon was loaded with about 1 cu. yd. of loose earth; then the grader stopped until the next wagon was driven up under the elevator, and this stop was never less than 10 secs. and very often 20 secs., even when teams were close behind one another. Even with the nine wagons it often happened that the grader had to wait half a minute or more for a wagon to reach its place, due to delays at the dump. The grader traveled 600 ft. before turning around, and in that distance loaded 15 wagons, generally taking 9 to 10 minutes to load them, then spending 1 minute turning around, if at the west end, or 2 minutes if at the east end. Thus, if we assume 15 wagons loaded in 11 minutes, including the lost time of grader in turning around, we would have 820 wagons loaded in 10 hours, provided there are no other delays. It is necessary, however, for the traction engine to take water at least twice a day in working hours, as well as before going to work in the morning and again during the noon hour. Since it takes about a quarter of an hour each time to take water, there is half an hour, at the least, so consumed, and during that half hour 40 wagon loads are lost, reducing the possible output to 780 wagons loaded per day. This output has been exceeded only once when 810 wagons were loaded, while the average has been nearer 750 loads.

As before stated, each load is about 1 cu. yd. of loose earth, which is probably equivalent to not much more than ⅔ cu. yd. of earth in place, thus making the daily output about 500 cu. yds. of earth measured in cut. This output is practically the same as on the Chicago Drainage Canal, where 12 horses were used instead of a traction engine for hauling each grader. Not including interest on wear and tear on plant we see that the cost is not far from 11 cts. per cu. yd. for loading, hauling, dumping and spreading. Since the "lead" is so short, it would be possible to move the earth at about the same cost using wheel scrapers, and the cost of the plant would be far less. Wheelscrapers, however, are always hard on horses, which a contractor has to consider when teams are scarce. The elevating grader is equally hard on horses where they are used instead of a traction engine, but it possesses a decided advantage over wheelers as the haul grows longer, and is therefore an excellent tool where borrow pits are long, comparatively level and in soil that plows readily. The grader and traction engine are easily turned in a roadway 55 ft. wide.

ROCK CUTS WITH STEAM SHOVELS.

Just west of Harrisburg, at West Fairview, the grading for the largest gravity classification yards in the world is now in progress. This grading covers an area nearly a quarter of a mile wide by three miles long, and 13 shovels are now at work upon it, while two more shovels will soon be installed. The layout of the tracks for these yards is not yet available, but an idea of their general character may be had from a study of the already finished gravity yards at Altoona, shown in Fig. 9.

The material is very largely shale, although there is much overlying earth and some underlying limestone in places. A force of some 3,000 men is at work here, under the contracting firm of H. S. Kerbaugh, Incorporated. Mr. George Nauman is the Assistant Engineer in charge of construction over this work and over the stone arch bridge across the Susquehanna at Shock's Mills. There are some 4,000,000 cu. yds. to be excavated in this yard grading, of which about 500,000 cu. yds. have been already moved.

Each of the 13 shovels is served by two to six trains of dump cars drawn by "dinkeys," a very common length of train being 10 cars. The Al-

FIG. 2. WEST PORTAL OF GALLITZIN TUNNEL.

lison dump car holding 4 cu. yds. water measure is used, and each car goes out heaped up in the center. Nevertheless it is very instructive to note that the swelling of the earth as well as the shale upon loosening is such that the average load of all cars has thus far been only 2.7 cu. yds. each. In shale the average car load has been 2.5 to 2.6 cu. yds., place measure, while in earth it has been very nearly 3 cu. yds. The same cars at another part of the line averaged 3.4 cu. yds. of sand. While nearly every contractor knows that earth swells when taken from the cut and placed in cars, still not a few would be surprised to find that a car holding considerably more than 4 cu. yds. of loose earth holds actually less than 3 cu. yds. place measure.

It is not so surprising that the shale, which breaks up in chunks both large and small, should swell as it does upon loosening.

The shovels work two 10-hour shifts each day, and it often happens that the night shift output is considerably less than that of the day shift. One shovel, for example, loaded 48,000 cars of shale in a given number of day shifts, but only 38,000 cars in the same number of night shifts. In good earth digging, however, and especially in hot weather, the writer has known the night shift to equal and sometimes to exceed the day shift output.

The face to which the shovels are working varies in height from 9 ft. to 60 ft., the latter being a face of shale and limestone, and the former being earth. The majority of the shovels used are model 60 Marion shovels, although a number of Bucyrus and Vulcan shovels of about the same weight are in use, and one model 80 Marion. This large shovel is served by four trains of 8 to 12 cars in a train, and working two shifts a day its output was 75,000 cu. yds. of clayey earth in one month, each car averaging 2.96 cu. yds. place measure. The face is about 20 ft. high by 40 ft. wide, and three dippersful every minute are averaged when working steadily, not including delays for moving, etc. Two dippers fill a car, hence, although the dipper holds nominally 2½ cu. yds., its actual average place measure is about 1½ cu. yds. Were there no delays or lost time of any kind, this shovel could load 2,700 cu. yds. in 10 hours at this rate; but every time that a train of 10 cars goes out, and the next train pulls into place there is a loss of 1½ to 2 minutes, and as it takes about 7 minutes to load 10 cars, we see that about 20% of the time is necessarily lost in such waits. Every half-hour the shovel has to move forward 5 ft. and this takes 4 or 5 mins., so another 10 or 15% of the shovel time is thus consumed each day. Then after making a cut about 1,000 ft. long the shovel has to move back to start a new cut and this moving back takes about 5 hours. We see that fully one-third of the working time of the shovel is lost in necessary delays, so that even where there are no accidents, 1,800 cu. yds. per 10-hour shift is the practical limit in this good material with a high face. The actual average for a month, as above stated, was 75,000 cu. yds. for two 10-hour shifts daily, or about 1,500 cu. yds. per shift, which is an excellent record. The crew consists of 6 pitmen, 1 pit boss, 1 dipperman, 1 craneman, 1 fireman, 4 locomotive engineers, 4 trainmen, 1 switchman, 14 dumpmen and 1 dump boss. There are besides about 12 trackmen to each shovel engaged on the work.

To move one of the 60-ton shovels a 2% grade was made from the railway station to the top of a hill 1½ miles away and tracks were laid to handle the excavation. Plans were subsequently changed and the shovel had to be moved back and to another part of the work. This grading, track laying and moving cost $6,000, which indicates the great amount sometimes expended in moving a shovel plant, and preparing to do work, especially where very heavy shovels are used.

USE OF WELL DRILLERS FOR BORING BLASTING HOLES.

One of the most interesting features of this steam shovel work is the use of well drillers mounted on wheels and operating a churn drill by a 4 to 8-HP. steam engine. These drillers are the common portable well drillers, using a bit 5⅜ ins. in diameter, and machines of the following makers are now in use: Star Drilling Co., Akron, Ohio; Keystone Driller Co., Beaver Falls, Pa.; and Gardner & Sons, Carlisle, Pa. There were nine of these well drillers at work but others had been ordered. The ordinary method of loosening cemented material and shale for a steam shovel is to drill holes 12 to 20 ft. apart, using the common churn drill operated by three laborers. A squib of several sticks of dynamite is fired in the bottom of each hole to "spring" it and make a chamber which is filled with black blasting powder. The deeper the hole the slower the drilling, for the added weight of the longer churn drills tires the men and makes rests more frequent. Hence a shovel must often work to a much shallower face than would be the case were power drills used. Using the well drillers a hole of 60 ft. or more in depth may readily be drilled in shale in 10 hours and the result is that the shovel has a working face three or four times as high as is possible with hand drilled holes. Anyone will appreciate the advantage of working to as high face as possible in that frequent moves of the shovel are avoided.

Not only do these steam driven well drillers effect an indirect saving in making a high working face practicable, but they also effect a direct saving in cost per foot of hole drilled.

A 4-HP. driller mounted on wagon wheels

FIG. 3. EAST PORTAL OF GALLITZIN TUNNEL.

weighs about 5,400 lbs., and in shale will drill three holes, each 18 ft. deep, or one hole 65 ft. deep in 10 hours, according to observations made by the writer. In clay or soapstone as high as 100 ft. of hole may be drilled in a day.

One of the nine machines was fitted with a traction attachment and being self-propelling saved considerable time in moving from hole to hole.

The crew on each of these machines consist of a driller and an engineman; a laborer is usually employed in carrying buckets of water from the nearest source of supply several hundred feet away. About 10 barrels of water are required for each 10 hour shift. On this particular work the actual cost of drilling by the well drillers has been about one-third as much as it was by hand.

In holes 25 ft. deep and 25 ft. apart, 7 to 10 sticks of 40% dynamite were used as a "squib;" then, in the chamber so made, 8 kegs (25-lb.) of blasting powder were charged. A series of holes is fired by electricity and the face of shale is thoroughly shattered.

In hard limestone the well drillers bore very slowly—5 to 10 ft. in 10 hours. This is largely due to the great diameter of the hole. A bit of about 3 ins. diameter bores a hole having only 30% as great an area as that of a 5⅝-in. bit. It seems likely, therefore, that better progress would be made if much smaller bits were used. For blasting purposes the smaller hole would be preferable since it requires much less tamping and the squib of dynamite is more effective in making a chamber.

Where tough limestone or similar rock is encountered the method of chambering does not pay, anyway, and the ordinary steam or air drill is doubtless preferable to the well drilling machine for holes up to 20 ft. in depth. But the well driller has a legitimate field and can hardly be excelled in soft rocks and shale, as the foregoing facts show.

THE GALLITZIN TUNNEL.

At the summit of the Alleghenies a new 3,600-ft. single track tunnel, known as the Gallitzin Tunnel, is being built. It parallels the old double track Allegheny Tunnel, and the two tunnels are 80 ft. c. to c. The cross-section of the excavated area of the Gallitzin Tunnel is shown in Fig. 1, where it is seen that in the bench, below the wall plate, there are 14 cu. yds. of excavation per linear foot of tunnel, and in the heading 5.6 cu. yds. Timbering, when used, is as shown in Fig. 1, but for the most part the roof has been so solid as not to require support. In Fig. 2, the west portal of the old Allegheny Tunnel is shown at the right and the new tunnel under construction at the left. A corresponding view of the east portals of the two tunnels is shown in Fig. 3, where the rubble bench wall, which is to support the concrete lining is shown. A clearer view of this bench wall and the timbering is had in Fig. 4. The top of

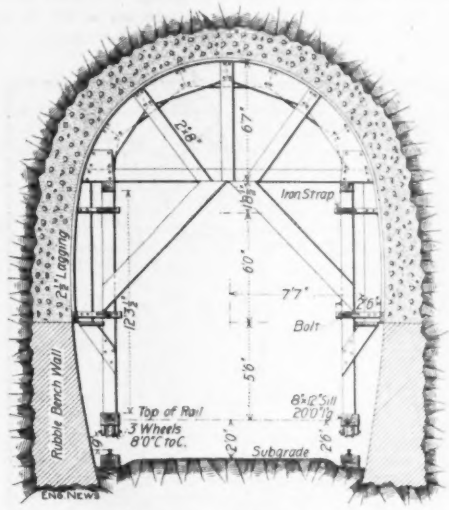


Fig. 5. Portable Frames Used in Lining Gallitzin Tunnel With Concrete.

this rubble bench wall is 5 ft. 6 ins. above the top of the rails, as shown in Fig. 5 which also shows the details of a traveling concrete frame designed by the tunnel contractor, Mr. P. F. Brendlinger.

LINING.—Above the rubble bench wall the lining is concrete, and this traveling frame is so designed that it can be raised 9 ins. off the rails by jacks. The side lagging rests on a plank platform level with the top of the rubble bench wall, and can be shifted in or out by loosening the bolts in the slotted iron straps, shown in Fig. 5. When a section of the tunnel 20 ft. long has been lined with concrete, and after the concrete has set, the side lagging frames are shifted back away from the fresh concrete, and the whole frame is lowered (9 ins.) on to the rails, ready to be moved ahead for the next section.

EXCAVATION.—A single heading is driven from each end of the tunnel, there being no shafts. In each heading there are four power drills operated by compressed air. There are two columns, on each of which two drills are mounted. Headings were at first 7 ft. high by 15 ft. wide, but have been gradually narrowed down to 10 ft. Each driller is now given a stint of four holes drilled 10 ft. into the heading face, although when the heading was wider each driller had to put in five holes. In the shale and shaley sandstone encountered the present requirement of 40 ft. of hole as a shift's work is readily met. The heading force goes in to work at 7 a. m., gets set up and begins drilling about 8 or 8.30 a. m., and the last hole is in by 3 p. m. The holes are charged and fired by 4 p. m., and the day's work on the heading is done, so far as drilling is concerned. The drilling force on each heading consists of four drillers, four drill helpers, one trimmer, one mucker, one timberman, one powderman and one foreman—a total of 13 men. While the holes are 10 ft. long, the actual advance after each firing is about 9 ft.

The six "cut holes" at the center are fired first, then the side holes on one side, then the side holes on the other side and finally the roof holes, making four separate shots for the 16 holes. Each hole is charged with 14 sticks of 40% Forcite gelatine, thus using three boxes for a charge.

The night shift consists of 14 muckers and a foreman, and, with two mules on dump cars, they tram the "muck" about 1,000 ft. (at present) to the bench, where the cars are dumped.

The bench is taken out in two lifts, as shown in Fig. 6. Two or three drills mounted on tripods attack the bench and widen out the heading. Three holes, 4, 6 and 8 ft. long, are driven on each side of the heading to widen out to the full dimensions. In the top bench four vertical holes are driven 7 ft. deep and two diagonal holes, located about 7 ft. back of the face. The bottom bench left after firing these holes is 14 ft. high, and five holes are drilled in it, two being as close to the sides as possible. The bottom bench holes are placed 12 to 14 ft. back of the face.

The four vertical holes in the top bench are "sprung" by firing 1 to 1½ cartridges in each hole, then the final charge consists of 5 to 8 cartridges in each hole. The holes in the bottom bench are "sprung" twice; the first time with two sticks in each hole, the second time with 10 to 14 sticks per hole, and for the final charge 40 to 60 sticks of Forcite are loaded in each hole. About 1,000 lbs. of Forcite are used each month in both ends of the tunnel.

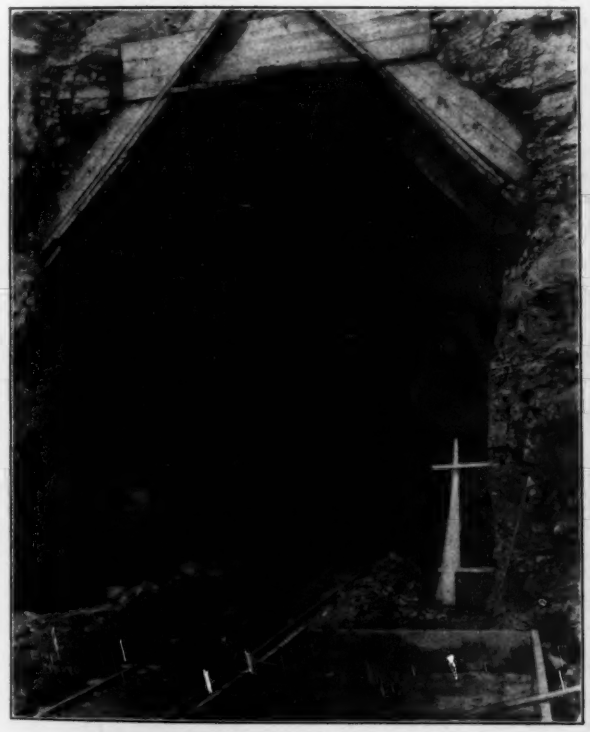


FIG. 4. TIMBERING OF GALLITZIN TUNNEL.

FIG. 7. STEAM SHOVEL WORKING IN GALLITZIN TUNNEL.

USING A STEAM SHOVEL IN THE TUNNEL.—Notwithstanding the fact that this is a single track tunnel a steam shovel is being used to load the cars at the face of the bench, as shown in Fig. 7. The shovel track is of necessity placed close to one side of the tunnel, and before firing the benches the shovel is run back a short distance. Compressed air is used for power on the shovel as well as on the drills, so that the "dinkey" that hauls the cars away is the only coal consuming engine in the tunnel. The "dinkey" has only 80 to 100 cars of "muck" to haul out each day. Notwithstanding the limited output of material possible under such conditions, the steam shovel is regarded by the contractor as a decided success in his tunnel work.

PROGRESS COMPARED WITH THE OLD ALLEGHENY TUNNEL.—In Drinker's "Tunneling," p. 325 et seq., will be found a description of the methods of work on the old Allegheny Tunnel, begun Nov., 1851, and finished in Feb., 1855, the two headings in 1903. We might go into the matter of timbering the roof and show what a change in methods has been evolved, and we might point out how concrete—then unknown—has replaced brick as a lining; but such a discussion would carry us beyond the limits of a single paper. It is interesting to note in this connection that the brick lining in the old tunnel is giving out badly in spots, so that the lining will soon have to be rebuilt. Both tunnels are on a 1% down grade from the west toward the east, and the last year being taken to place the brick lining.

It would be difficult to find a more striking object lesson than these two tunnels furnish. On the old tunnel, built half a century ago, hand drilling was employed entirely, and work was pushed from six headings, there being four shafts. The average progress on each heading was 15 ft. a week, as compared with 50 ft. a week on the Gallitzin Tunnel, which, being in exactly the same kind of material, gives us an excellent standard for comparison. With their six headings in 1853, the weekly progress was actually less than with Drinker makes a slight error in stating that the Allegheny Tunnel has a 90-ft. per mile grade.

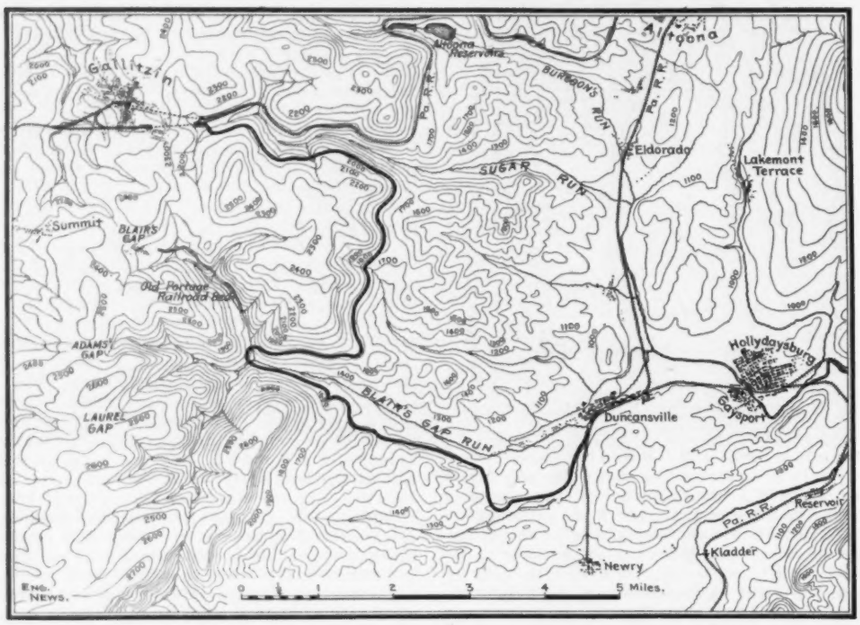


FIG. 8. MAP SHOWING THE NEW GALLITZIN- HOLLIDAYSBURG CUT-OFF.

CHANGES IN ALINEMENT.

As stated in the forepart of this article, it would be profitless to merely enumerate the many changes in alinement that are being made. Nor would it be of any particular value to give the number of degrees of curvature eliminated on each change, or the total cost of reducing the curvature, and the like. It is interesting to note, however, that after crossing the summit at Gallitzin, there will be no grade greater than 0.3% against traffic going to Philadelphia.

In coming east the road rises on a 1% grade to the summit, and then descends with a maximum of very nearly 2% (100 ft. per mile) to Altoona. There is now being completed a new cutoff, shown in Fig. 8, that will reduce this maximum to 80 ft. per mile. The famous horseshoe curve on the old main line is shown at the upper part of the map. The historical Portage Railroad is also shown at the point where the new line makes the semicircular curve.

Our map (Fig. 8) of this summit location was made from advance photographic proofs of the Hollidaysburg and the Ebensburg Quadrangles, which the Director of the U. S. Geological Survey kindly furnished us. As we study the contours of this map the question very naturally arises whether the old location of the Pennsylvania R. R. would ever have been made had such a map existed at the time of the original location.

OPEN CUTS VS. TUNNELS.

Examining the contours at the Gallitzin tunnel and those of Sugar Run Gap, a few hundred feet to the south, we are led to ask why the new Gallitzin Tunnel is being built at all. It would seem that an open cut could have been made at the Sugar Run Gap, without exceeding a depth well within economic limits. One of the long open cuts recently made on the Pennsylvania R. R. is 160 ft. deep, and it possesses a great advantage over a tunnel in that it can be cheaply widened by taking off a slice on either side.

Looking back upon the wonderful growth of traffic on this railway, may not the years be few in number before the time comes when the projected six trackways through the summit tunnels will be found inadequate?

The single track Gallitzin Tunnel is costing $475,000, and for that sum of money 800,000 cu. yds. of open cut excavation in shale and sandstone could be made. A rock cut 160 ft. deep, 40 ft. at base, slopes ½ to 1, and 1,100 ft. long, would cost no more than the Gallitzin Tunnel. The State Tunnel through Sugar Run Gap is only 1,600 ft. long, hence it could be replaced by an open cut at not much greater cost than the 3,600-ft. Gallitzin Tunnel. It is true that much of the shale will assume a permanent slope flatter than ½ to 1, and in certain cuts it is subject to bad slipping, all of which tends to offset the advantages of open cutting.

The foregoing observations are not to be taken as a criticism of the engineers who designed the present work, for doubtless other conditions with which we are not acquainted influenced their decision. But we take this work rather as an object lesson to emphasize the desirability of making open cuts to depths that would not have been dreamed of a few years ago. Cheapened means of rock excavation and the steam shovel have vitiated all rules as to economic depth of open cut.

The old Allegheny Tunnel also shows that brick masonry in a tunnel is far from being everlasting. Tunnel linings subject to the acid gases from locomotives are apt to be comparatively short lived—and who can say that even concrete may not in time disintegrate under such conditions?

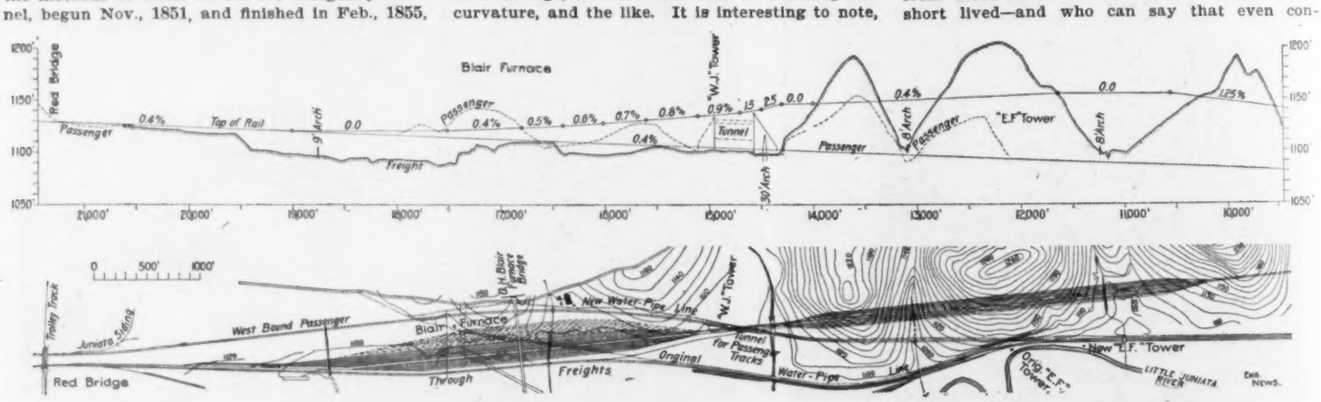


FIG. 9. PLAN AND PROFILE OF THE ALTOONA WEST-BOUND GRAVITY YARD.

ACKNOWLEDGMENTS.

For many courtesies we wish to thank Mr. William H. Brown, Chief Engineer of the Pennsylvania Railroad Co.; Mr. George Nauman, Assistant Engineer in charge of construction near Harrisburg, and Mr. W. K. Martin, Assistant Engineer in charge of construction near Altoona. We desire also to thank Mr. P. F. Brendlinger, contractor for the Gallitzin Tunnel, and the firm of H. S. Kerbaugh, Incorporated, for data and for assistance in going over their work.

A FURTHER REPORT ON WATER CONSUMPTION AND WATER WASTE IN NEW YORK CITY.

In our issues of Feb. 5 and April 9, 1903, there were given some of the results of the investigation of water waste in New York City being carried on by the Department of Water Supply, Gas and Electricity, under the direction of Messrs. Robert Grier Monroe, Commissioner, and Nicholas S. Hill, Jr., Chief Engineer, and with the aid of Mr. Edward S. Cole.*

A further report on this subject, made by Mr. Hill and addressed to Mr. Monroe, is given below, except that a few local references and some of the tables and diagrams are omitted. The report as condensed is as follows:

I beg herewith to submit for your consideration my third report on the water waste investigations which have been carried on from December, 1902. Since my last report, at which time eight districts had been covered, four additional districts have been surveyed, one additional district completed (except for the financial statistics which have not been received from the Water Registrar's office), two districts have been resurveyed for purposes of comparison, and the resurvey of a third district is nearly finished. The total area included to date in Manhattan is about 1,400 acres, or 11.5% of the area of the island. As this area includes districts representative of typical sections of the borough, such as a down-town business, an east side tenement house, the Murray Hill, an upper west side apartment house district, and others, some idea may be had of the general conditions prevailing. In addition, special investigations have been made upon the high service district as a whole, tests have been conducted at the several pumping stations in Manhattan to determine the correct amount pumped at the various stations, and extensive tests have been commenced in conjunction with Mr. Watkins, Division Engineer of the Aqueduct Commission, for the purpose, if possible, of determining the exact total flow of water through the aqueduct, with the water at different levels. Mr. Cole, with the pitometer placed on all large mains leading to the city, has taken readings on the same days and at the same intervals with Mr. Watkins, who took readings from a Buff and Berger current meter at a point on the new aqueduct below Dunwoodie.

The reduction in the per capita consumption as a result of considering the non-resident population in District No. 1 (Murray Hill), as shown in the report of March 31, is even more forcibly exhibited in District No. 8. According to the census returns, the population of the No. 1 district was 8,396. The non-resident population estimated by canvass is 3,760. The net per capita consumption, in the last survey of this territory, based on resident population, was 170, and including the total population, 117.5 gallons per day.

In District No. 8, which includes the area between Fulton St. (one block south of the General Post Office and the Astor House.—Ed.) and the Battery and from East to North River, the resident population is 11,000, and the non-resident, determined by canvass, 103,000. The net per capita consumption, after deducting leakage, for resident population, 825; and for resident and non-resident, 79.2 gallons per day.

The survey of the last-named territory also developed a large consumption of water for power purposes. A canvass of all buildings was made to determine the total horse power represented for lighting, heating and power purposes. Incidentally, a tabulation was made of the total number of faucets, closets, urinals and other fixtures, which is interesting, as showing the lavishness of American practice in this regard, both in commercial and residential buildings. Table I. shows the results of this canvass.

TABLE I.—Summary. Special Inspection of Water Fixtures and Water Consumption of District No. 8, Feb. 20 to March 13, 1903.

Buildings examined	2,094
Buildings metered	1,972
Total floor space (ground floor, sq. ft.)	4,945,172
Floors	10,386
Closets	13,066
Urinals	5,396
Faucets	33,547
All fixtures	52,009
Private plants for light	111
Private plants for heat	337
Private plants for power	160
Electric elevators	227
Hydraulic elevators	421
Steam elevators	59
Gas elevators	4
Belt elevators	2
Water tanks	701
Total capacity in gallons	1,243,712
Measured leakage in fixtures, gallons	423,764
Leaking closets	1,210
Leaking faucets	728
Horse power of boilers in use	44,340
Water used for power purposes, gals. daily	1,750,000
Average power factor 40%, per capita	15.3
Net per capita consumption based on total population and corrected for power purposes, daily	64

*In the first-named of the two issues of this journal mentioned above there also appeared an illustrated description of the Cole-Flad photo-pitometer, which is being used by Mr. Cole in his work.

It is seen from the foregoing that 15.3 gallons are used for the development of power, reducing the consumption for other purposes to 64.2 gallons per capita per day. The small percentage of leaking closets and faucets in this area is interesting to note, there being but 1.938, with a total of 52,009 fixtures. The gross leakage is only 423,764 gallons, or 4.47% of the total consumption. The total consumption is 9,450,000 gallons per day.

This, in conjunction with the fact that 1,987 buildings out of 2,384 are metered, and only 5,379,000 gallons per day are accounted for by the meter records of the Department, leads to one of three conclusions: (1) Either the main leakage in this district is excessive, (2) the buildings supposed to be covered by meters are obtaining water through other connections unrecorded, (3) or the meters are defective.

Undoubtedly the mains in this district are old and probably in bad repair, but owing to the condition of the valves and the manner of making the service connections, it was impossible to subdivide the territory and explore for defective mains. The per capita consumption, however, in comparison with other districts and cities, is not high, and not what might be expected when it is considered that in addition to the non-resident population accounted for, there are thousands of transients who spend the working day and lunch in this vicinity.

There probably is leakage from mains, but my analysis would tend to show that the great discrepancy is due largely to one or two of the latter causes, and is an additional argument in favor of furnishing the necessary funds to provide for an adequate and competent corps of inspectors to properly care for meters and metered connections.

The condition of the meters and services is also largely due to the fact that the city, contrary to the custom in most American cities, allows the plumber to make the connections and set the meter, and the meter is owned by the owner of the premises. The city should control all meters and services, and keep them in proper repair.

As further illustrating the effect of industrial and commercial use upon the consumption of water: In District No. 7 there is a total of but 295 buildings in an area of 260 acres, of which 251 are unmetered and 44 metered. The unmetered consumption in this district on the last test was 766,100 gallons; the metered, 776,900 gallons, or slightly more. The 44 meters represent almost exclusively manufacturing plants or railroad yards, and as a result the per capita consumption is doubled. The investigations in this district developed the fact that one large consumer supposed to be metered had connections back of the meter. The effect of the discovery is shown in a comparison of the two surveys, one made before and one after the connections were changed:

	First test.	Second test.
Gallons metered daily	551,900	776,900
Gallons paid for frontage rates	1,048,100	766,100
Revenues from meter bills	$26,931	$37,910
Revenues from frontage rates	3,858	3,858
Total Revenue	$30,789	$41,768
Revenue per M. gallons	.055	.0742
Night rate of net unmetered consumption per capita	229	106.09

While the resurvey indicated no diminution of the per capita consumption, which is high, probably due to the fact that other similar connections may be discovered, which would show the water is used for commercial purposes, at the same time the table is most interesting as demonstrating the results derived from careful inspection and measurement. The mains in this district are new. The sewer inspections and other tests revealed no main leakage, and the house leakage is small, so that continued investigation will lead rather to increased revenue than decreased consumption.

The great reduction in the night rate of net unmetered consumption per capita shows how easily results may mislead. In the first test, water which should have been metered and accounted for in commercial consumption was charged to frontage, making a high percentage of night to average flow which would indicate heavy leakage. This does not exist.

Another illustration of the same kind may be found in District No. 12, including the area between 86th and 103d Sts., and Second Ave. and the East River. The nominal consumption in this section as measured is 2,750,000, which equals 51.3 gallons per capita, net. Located in the district is a large power house which uses 1,500,000 gallons per 24 hours. This water should be rightfully added to the consumption. The amount was large, however, and in view of the fact that a through 48-in. trunk main serving a district further down-town passed near the station and the pressures were then low in the area in question, connection was made to the 48-in. pipe. If this were added we have a net per capita of 90 instead of 51.3 gallons per day as the true consumption. Put in another form, the per capita use in the No. 12 district, with 40,000 population, is nearly doubled by one station. The commercial use of water in this area, adding the supply of this station, is 62 gallons per capita per day. This 62 gallons represents metered water. Referring again to the effect of non-resident population upon per capita consumption, it may be conservatively estimated that 600,000 people come to Manhattan daily. The per capita consumption in Manhattan is about 129 gallons; if this population is included this figure is reduced to 99.6 gallons per day.

A further study of the situation does not reveal a large leakage in the mains. The sewer and subway inspections revealed nothing serious.

On the other hand, the lack of proper supervision of the plumbing has led to serious losses. In the last report the waste from this source was estimated at 32,000,000 gallons per day. The information subsequently obtained would tend to increase this amount to 42,000,000 gallons. This represents the actual daily loss due to faulty fixtures. In addition, owing to the class of plumbing tolerated, much water is wasted on account of the custom of opening fixtures to prevent freezing in winter. In summer a large amount is lost in cooling the water. In a majority of houses it will be found that the hot and cold water risers are placed side by side in a common trough. Owing to the poor system of circulation a large quantity is run in an endeavor to obtain hot water. These conditions cannot be improved to-day without great expense to the property owner, and a movement to effect a change at this date would probably meet with forceful opposition. It is possible for the city, however, to pass the proper plumbing laws and employ capable inspectors who will see that only good work is installed hereafter. It is impossible to estimate this loss, but it is safe to assume that it will almost equal the waste due to faulty fixtures.

Figuring on this basis, therefore, for the purpose of arriving at a preliminary, but not by any means final conclusion, we have:

	Gallons.
Per capita consumption of Manhattan, resident population	129
Per capita consumption of Manhattan resident and non-resident	99
Per capita consumption after deducting losses due to faulty fixtures and plumbing	68
Deducting 15 gallons per day for power uses (which is low), the per capita consumption for all domestic and commercial purposes, including main leakage, is	53

Table II.—Summary of Water Waste Inspection, New York City.

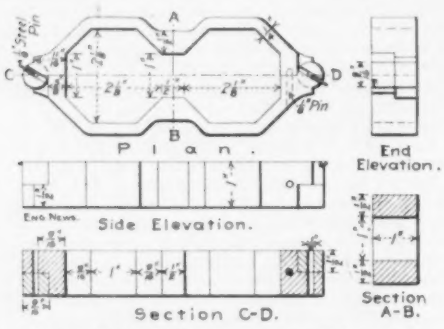
No. of waste district.	Total acres in borough.	Area waste district.		Total consumption daily.	Gallons metered daily.		Gallons leakage in fixtures.		Population.		Gross per capita consumption, gallons.		Total revenue 1000 gallons.	Total revenue metered and unmetered.
	100 per ct.	Total	Per ct.	100 Per ct.	Total	Per ct.	Total	Per ct.	Resident	Total	Resident	Total	Approximate	Yearly
Borough of Manhattan.														
1		127		1,470,000	638,000	43	42,429	3	8,396	12,156	175	121	$.0720	$49,115
2		70		1,440,000	293,000	20	369,000	26	38,906	38,906	37	37	.0988	51,805
3		168		5,400,000	940,000	17	672,500	12	90,000	90,000	60	60	.0498	98,485
6		58		760,000	160,500	21	87,200	11	10,164	10,164	74.8	74.8	.0997	19,300
8		230		9,450,000	5,379,000	56	423,764	5	11,000	114,000	860	83	.0768	269,131
9		75		1,366,000	156,300	11	119,500	9	8,872	8,872	154	154	.0520	25,895
10		310		20,293,000	1,838,000	9.08	1,217,000	6	218,000	218,060	92.7	92.7	.0257	189,763
11		196		4,888,000	364,000	7.4	1,100,000	22.5	43,800	43,800	111.6	111.6	.0539	96,251
12		204		2,750,000	977,000	35.5	697,000	25.2	40,000	40,000	68.5	68.5	.0866	87,619
Total,	12,576	1,438	11.4	47,727,000	10,745,800	22.4	4,728,393	9.9	469,138	575,898	101.7	83.2	$.0566	$886,824
Borough of the Bronx.														
5		174		1,730,000	86,000	4.9	329,479	18.8	32,200	32,450	54.3	54	$.0674	$43,023
7		260		1,543,000	776,900	50.4	125,646	8.1	3,076	6,076	502	256	.0742	41,768
Total,	26,522	434		3,273,000	862,900	26.2	455,125	13.8	35,276	38,526	93.5	85.6	$.0706	$84,791
Total for Boroughs of Manhattan and the Bronx.														
	39,098	1,872		51,000,000	11,608,700		5,183,518		504,414	614,424	101.1	83.2	$.0521	$971,615

Estimated Total Plumbing Leakage.

Manhattan—4,728,393 gallons is 11.4 per cent. of 41,500,000 gallons per diem, which, at meter rate, = $2,020,000 per annum
The Bronx—Estimate based on pop., as above, 2,710,000 " " " " " = 132,000 "
Total estimate leakage, Manhattan and the Bronx = 44,210,000 " " " " " = $2,152,000 "

HOME-MADE CEMENT TESTING MACHINES.

We have recently received from a subscriber in Macleod, Alberta, a request for a description of a home-made testing machine, stating that he cannot afford to purchase a regular machine. It may be said in reply that if any considerable amount of testing is to be done and time is of any value, one cannot afford to use anything else than a regular machine of first-class design. Further, if tests are to be made the basis for acceptance or rejection of cements, then a regular machine will give results which are not so likely to be questioned as results secured on a home-made machine of any sort.



Home-Made Molds for Cement Briquettes.

However, for engineers who desire to test cement in a small way for their own satisfaction, and cannot afford to buy a regular testing machine the best thing to do, we believe, is to make transverse tests. Anyone with enough ingenuity to have any claim to the title of engineer should be able to improvise an apparatus for making rectangular briquettes for transverse tests and rigging a platform scale or a spring-balance apparatus to break them. In our issue of Dec. 14, 1893, we published a thesis by Messrs. Abbott and Morrison of the Thayer School of Civil Engineering in which extensive researches in the transverse testing of cement were set forth.

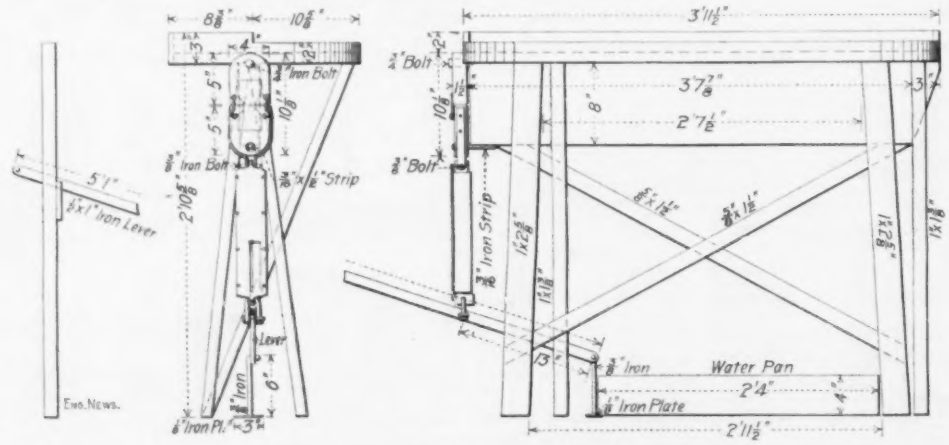
For those who desire a home-made machine for tensile tests, we know of none better than the one described by Mr. P. F. Brendlinger, M. Am. Soc. C. E., in a paper read in 1885 before the Engineers' Club of Philadelphia, and published in Vol. V. of its "Proceedings," p. 194. As the paper is now accessible to very few, we reprint its substance below, and have redrawn the cuts accompanying it.

Immediately after commencing the construction of the Reading & Pottsville Ry. (last spring), cement manufacturers poured into my office, at Pottsville, with their wares; as usual, each manufacturer had the best brand, and backed up his statements with innumerable testimonials and tabulated statements, showing very fine results. I used some of these cements for a month, and by various crude tests satisfied myself I was getting a variable cement, some good and some bad. My principal assistant engineer, Mr. Chas. S. Churchill, and I then put our ideas together to construct a cheap testing machine. Fig. 1 is a side elevation. The framework consists of an ordinary trestle I found lying around. An ordinary carpenter put on the top or table and made the wooden clamp at the end to hold the briquettes. The upper clamp is made entirely of oak, while the lower is bound with a strap of iron, and holding the spring balance reaching 100 lbs. A lever 5 ft. 1 in. long is attached to the lower clamp and is kept from moving laterally by a vertical slit used as a guide in a board near the end of the lever; this insures a square break of the briquette. A small button holds up the lever when not in use. The upper clamp has two brass hooks which catch in two eyes on the lower clamp, which hold the clamp together while putting in the briquette; then they are uncoupled, and the briquette is broken by means of a lever, etc. The lower clamp has a hole bored through it, into which an iron rod extends fastened to the trestle; this is for the purpose of stopping the fall of the lower clamp and balance after the briquette is broken. There is sufficient play around this bolt, so that no part touches while the strain is applied. The water pan is shown under the machine and is made of galvanized iron. Fig. 2 is an end elevation and Fig. 3 shows the briquette molds.

The entire cost of this machine as built is $12, and by a few changes, the cost can be very much reduced; and on railways where carpenters and blacksmiths are constantly employed, and paid by the month, a machine can be turned out some rainy day that will not cost over five or six dollars.

To obtain the exact breaking strain of a briquette, the number of pounds is read on the balance, and 4 lbs. added for the weight of the lower clamp and balance. The briquettes are made in two ways: one of pure cement and immersed in water in the pan, and kept there for 24 hours, when they are broken; the other, a mixture of two parts sand and one part cement, kept immersed for seven days, then broken. This machine will not show as high results as are obtained from Riehlé's or Fairbanks' machines; but the comparative results between different cements can be just as readily obtained, and when a certain brand is once adopted, the uniformity of the cement can be just as well determined as in a better machine. There have been over 600 tests made this season in this machine.

I might add that a better and perhaps higher breaking strain can be reached by suspending from the end of the lever, a bucket, and having a hopper above it, filled with sand or shot, which would run into the pan, and thus put the strain on the briquette gradually.



A HOME-MADE CEMENT TESTING MACHINE.

ANNUAL CONVENTION OF THE CENTRAL STATES WATER-WORKS ASSOCIATION.

The seventh annual convention of the association was held at Dayton, O., Sept. 15 to 17, inclusive. At the same time and place there was held the first meeting of the Ohio Boards of Public Service. Two of the sessions of the two bodies were held jointly, and the joint registration included some 225 members and guests of the two organizations. A large part of the three days was taken up with general business, to which further reference will be made, and with excursions, other forms of entertainment, and exchanges of personal experiences. An abstract of the papers and the discussions of the same follows:

THE POLLUTION OF STREAMS AND WATER SUPPLIES IN OHIO.

The first paper presented was by Dr. C. O. Probst, Secretary of the Ohio State Board of Health, and reviewed the studies of the character of public water supplies in Ohio, carried on by the state board of health since 1897.

An investigation, in 1901, showed that in the portion of the Ohio River drainage area located above the new intake for the Cincinnati waterworks, there is a population of 1,961,922, living in 291 communities of 1,000 population and over. This intake is located at the new works now being constructed at California, above the city of Cincinnati and its suburbs. Of the numerous plants taking water from the Ohio River above the intake, many of which are near the Pittsburg center of pollution, but few attempt to purify the water. The new plant for Cincinnati will include purification works, some features of which are described further on.

Speaking of Lake Erie as a source of supply, Dr. Probst called attention to the shallowness of the lake, its muddiness on account thereof, and of wind action, and the shifting direction of the currents. Continuing, the speaker said:

No city can expect to run its sewage into this lake and take a pure supply of water out of it. The result of the Cleveland experiment may require this statement to be modified. They propose to carry all their sewage ten miles to the east of their lake intake, which is also to be extended. This will no doubt greatly improve their supply. Muddy water they will certainly have at times. A satisfactory public water supply must be clear, and it is extremely probable that Cleveland will yet be compelled to resort to filtration.

Lorain and Conneaut have filtered lake supplies. Lorain put in filters in 1896. They have been highly satisfactory as regards reducing the deaths from typhoid fever. An attempt to cheapen the process (at Lorain only?—Ed.) by substituting iron for alum was a failure. The filters did poorer work, and were much damaged by the experiment. Last July it was necessary to shut down the filters to repair them.

The typhoid history of Lorain is worthy of a paragraph. Using a polluted lake water, they had 43 deaths from typhoid in the five years prior to putting in the filters, or 8 3-5 per annum. In the five years following eleven deaths, or 2 1-5 per annum. Until August this year there had been no deaths from typhoid. The filters were shut down in July, as stated, and within six weeks thereafter they had three deaths from this disease.

Conneaut has had an interesting experience. In 1899 her Cook wells failed to supply enough water, and the lake intake was opened. A serious outbreak of typhoid followed, which seemed clearly traceable to the lake water. Filters were introduced in 1899 and there was no more typhoid for some time. But another outbreak occurred in 1901. It was shown that just preceding this little or no alum was used. Filters should be operated on the scale of efficiency and not of cost, and water-works officials should be held strictly accountable for cheating of this kind.

None of the streams of Ohio, with but few exceptions, now afford "water of sufficient purity for a safe domestic supply," and of the exceptions the speaker said:

The head waters of a few streams by impounding and sedimentation may still furnish a fairly safe and satisfactory supply for smaller towns that are accessible to them. Such towns will be better off with a ground water supply where it is obtainable.

In conclusion I would say that we can never hope to keep our streams fit for domestic water supplies, police them as we may. Our large cities must look to purification as their only remedy; but no matter what form of purification is provided it is better that the raw water should be as pure as possible.

In opening the discussion on this paper, Mr. Joseph Pater declared that the streams of the State are being made open sewers, and that the practice should be resisted and prohibitive legislation secured. Mr. Jerry O'Shaughnessy thought that the enforcement of existing legislation was all that is needed, and asked whether the State Board of Health was not the proper body to enforce the laws. In reply to this question Dr. Probst said that the board could do nothing but investigate pollution, and then report violations of the law to municipal authorities, whereupon the latter had power to prosecute. There is law enough, but the public generally is not awake to the situation. Mr. E. P. Matthews, City Solicitor of Dayton, O., said, in effect, that the cities could not be expected to make much progress in preventing pollution so long as they were equal offenders with other violators of the law.

THE METER SYSTEM IN CLEVELAND, O.

The following is an abstract of a paper by Mr. Edward W. Bemis, Superintendent of Water-Works at Cleveland:

During the 26 years prior to 1902 the meter system in Cleveland had been gradually introduced upon substantially all business premises, with the exception of some small stores and saloons. There were in use 3,640 meters and elevator indicators, but, nevertheless, the consumption of water had increased from 111 gallons per day per capita in 1891 to 169 gallons in 1901, while the consumption of water from 1 to 4 a. m. was over half as great as the rate during the two or three hours of maximum use in the morning and afternoon. Less than 500 houses were metered, and it was determined to meter as rapidly as possible the entire 53,000 unmetered services. During 1902 there were 7,700 meters installed, and up to Sept. 1, 1903, the additions numbered 8,300 more. We now have 19,300, while the department is setting at the rate of over 12,000 a year, at an average cost for all

styles of setting of $14 for each ⅝-in. meter. This includes the cost of the Trident meter, $6.50, and the setting thereof. If the setting is near the curb the meter is usually now set in a cement pipe, although wherever practicable it is placed in the basements at an average cost of $10.60, including the meter.

The result of all this is as follows: The increase in the consumption of water was 22.5% from 1891 to 1894 and again the same from 1894 to 1897, and 38.7% from 1897 to 1900. But during the first eight months of 1903 there was an actual decrease of 6.6% below the consumption for the first eight months of 1900, and indications are that the whole year 1903 will show more than 7% decline from the pumpage of 1900, despite the very large growth of business and population. The consumption per capita has fallen from 169 in 1901 to less than 145 this year, and will continue to fall steadily while the remaining 36,000 services are being metered during the next three years. The great saving from the meters has been that it has obviated the necessity for large extensions of pumps, buildings, feeder mains, etc., which would otherwise be necessary. This saving far more than counterbalances the cost of the meters.

There appears to be no marked saving in operating expenses, because the reduction in cost at the pumping station and in house inspection is counterbalanced by a necessary increase in the office force and meter readers.

The paper closed with an account of the methods of meter setting and of the successful and interesting measure which had been taken to popularize the meter system in Cleveland. This feature is to be presented with considerable fullness by Superintendent Bemis in a paper before the League of American Municipalities at its Baltimore conference on Oct. 7.

In answer to an inquiry from Mr. W. A. Veach, Mr. Bemis stated that in order to popularize the introduction of meters and hasten their use on all services the department did not begin by forcing the meters on those known to be wasting water. Instead, attention was turned to consumers who would be benefited by the use of meters. Mr. Jerry O'Shaughnessy inquired about the sliding minimum rate in force at Cleveland, which to him was an innovation. Mr. O'Shaughnessy continued, and this phase of the discussion proceeded as follows:

Wasn't it your idea to make the meter system popular by giving a low rate?—that is, an apparent low rate, but what is really a high rate to the domestic consumer? In other words, you lowered your rate to the domestic consumer to such a small rate that the city would lose, or at least have an unprofitable business. Now to overcome that you put on a minimum to help you out. Wouldn't it have been better to have put the rate at a figure where the city could afford to furnish that water to all consumers alike, and leave out the minimum rate?

Mr. Bemis.—We did not change our rate for metered water from what it had been for some time—40 cts. per 1,000 ft., or 5½ cts. per 1,000 gallons. Every domestic consumer in the city, with 500 exceptions out of about 54,000, was paying on an assessment basis. We took the assessment basis and created for them a minimum lower than the assessment; so that unless they use an extravagant amount of water everybody will gain; 90% have gained, and if we had not put the minimum on many of them would have gained still more, to be sure, and it might have been in the long run a fairer and juster system. We argued with the people that it was a nearer approach to justice to have a minimum that was lower than the assessment. It would enable most people to reduce their water bills, and at the same time save the department from the danger of too great a reduction of revenue. Experience has shown that we could, however, have stood a scheme such as you suggest of no minimum, but since our expenses are so very large for the introduction of these meters, until we have metered the city we want all our revenue for that purpose, and we think we had better keep the minimum just as it is until the city is all metered; as long as everybody is practically gaining by that minimum they do not kick much against it.

Mr. O'Shaughnessy also thought that a minimum rate encourages waste of water by all who would otherwise fall below the rate. Mr. Bemis replied that at Cleveland metered consumers were paying for what they used, and that even though the meter rate is only 5½ cts. per 1,000 gallons the city would get rich if it realized at that rate on all the water pumped, half of which now yields no revenue whatever.

THE NEW WATER PURIFICATION WORKS AT CINCINNATI.

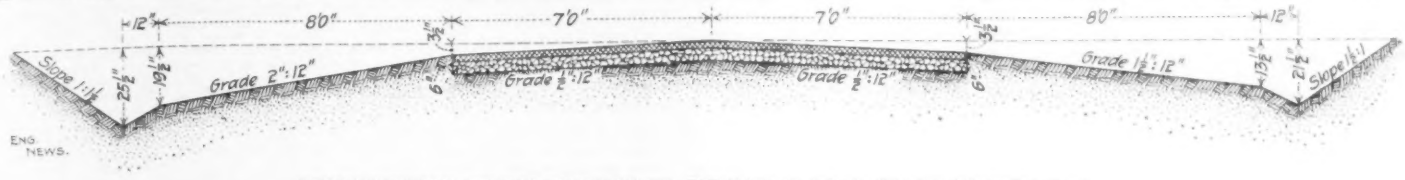
The new features brought out by Mr. Frank J. Kelley's description of these works related chiefly to the mixing basins and filters, and has been condensed as follows:

The water from the settling basins is discharged into a well and this is connected with the mixing basins. There are two of these basins, one having a capacity of 20,000,000 and the other a capacity of 2,000,000 gallons of water, which will be used at different times, depending upon the condition of the water in the river; the larger one being used when the river is muddy.

As the water flows from the well it passes through a grating made of perforated pipes into a large pipe connected at regular intervals with smaller pipes, which in turn discharge into the mixing basin.

The water as it passes the grating is mixed with diluted alum in portions of 1 to 4 grains of alum per gallon, the average being 1½ grains. The alum is introduced through the perforated pipes forming the grating. From the mixing basins the water flows on through the filtering beds.

The filtering beds will be 36 in number, and each will be about 50 ft. long, 26 ft. wide, and 8 ft. deep. They will be constructed of concrete, and the water from them will flow to the tunnel leading to another pumping station in the city, about four miles west.



CROSS-SECTION OF PROPOSED 30-FT. BITULITHIC ROAD, SALEM COUNTY, N. J.

Each filter will have a daily capacity of from 2,500,000 to 3,000,000 gallons. The total capacity being 80,000,000 to 108,000,000 gallons daily.

OTHER PAPERS AND ADDRESSES.

Mr. Jas. R. Maxwell, C. E., read a paper entitled "The Proper Care of Pipe and Conduit Systems," which was really on experiences, some years back, with force mains not provided with air vents at summits, followed by some criticisms of the new water-works tunnel at Cincinnati. The tunnel is some 22,250 ft. long, and the speaker believed it might with much greater safety have consisted of two 60-in. cast-iron pipe lines laid a good distance apart; since the tunnel, he believed, was liable to occasional pressures which would come dangerously near if they did not exceed the factor of safety of the masonry conduit.*

A brief description of the driven well system of Dayton, O., was given by Mr. Harry J. McDargh, C. E. The system includes 94 wells, 8 ins. in diameter, 25 to 89 ft. deep, the varying depths being designed to draw from different levels.

Mr. W. R. Hill, M. Am. Soc. C. E., in response to a request, described briefly and informally the new Croton aqueduct and dam.

Mr. Thos. R. Cook, C. E., of Toledo, O., read a paper on "Repairs to Submarine Water Pipe," portions of which we hope to reprint in an early issue.

Mr. C. W. Wiles presented a somewhat detailed history of the Central States Water-Works Association from its inception.

BUSINESS AND PLEASURE.

The report of the treasurer showed a balance of $35 a year ago, receipts during the year of $449, and a current balance of $76. Seven active members and one associate were elected during the convention.

Toledo, O., was chosen as the place for the convention to be held in 1904, and it was understood that the Ohio Boards of Public Service will meet with the Central States Water-Works Association at that time, and whenever the latter body meets in Ohio.

The leading officers elected for the year 1903 are as follows: President, Frank J. Kelley, Cincinnati, O.; Secretary, Wm. A. Veach, Newark, O.; Treasurer, Chas. F. Rowe, Dayton, O.

During the convention visits were made to the National Soldiers' Home, the works of the National Cash Register Co., and of the Smith-Vaile & Stillwell-Bierce Co., and to the pumping station of the Dayton water-works. A list of the exhibitors is given in our Construction News Supplement.

THE DESIGN OF A BITUMINOUS MACADAM ROAD FOR SALEM COUNTY, N. J.

The accompanying cross-section, Fig. 1, shows the design of a proposed "bitulithic road" some five miles in length, in Salem county, N. J. This class of country road construction is somewhat novel, although bitulithic pavements on city streets are by no means new. The specifications for the work may therefore prove of interest to many of our readers, and so far as they relate to the pavement we print them in full as follows:

*The author appeared to misconceive the conditions at Cincinnati which, if we understand them and his ideas, will not give rise to the pressures which he discusses.—Ed.

SPECIFICATIONS FOR "THE BITULITHIC PAVEMENT."

FOUNDATION.—On top of the sub-foundation shall be spread a layer of hard crushed stone to a depth of 6 ins., which shall then be compressed with a 12-ton steam road roller. This shall be coated with a thin layer of Warren's No. 1 Puritan brand bituminous semi-liquid cement, said bitumen to be sufficiently flexible to unite freely with the cold stone.

On top of this No. 1 composition shall be spread a heavy coating of Warren's No. 24 Puritan brand hard bituminous cement for the purpose of firmly binding the foundation together and making it readily unite with the bituminous concrete wearing surface. One gallon of the bituminous cement will be used to each square yard of surface. On this prepared foundation shall be laid the wearing surface or pavement proper, which shall be composed of carefully selected, sound, hard crushed stone, mixed with bitumen and laid as hereinafter specified.

(a) WEARING SURFACE.—After heating the stone in a rotary mechanical dryer, to a temperature of about 250° F., it shall be elevated and passed through a rotary screen, having six or more sections with varying sized openings, the maximum of which shall be 1¾ ins. and the minimum 1-10-in. in diameter. The several sizes of stone thus separated by the screen sections, shall pass into a bin containing six sections or compartments. From this bin the stone shall be drawn into a weigh box, resting on a scale, having seven beams. The stone from each bin is accurately weighed in the proportion which has been previously determined by laboratory tests to give the best results; that is, the most dense mixture of mineral aggregate, and one having inherent stability. From the weigh box each batch of mineral aggregate, composed of differing sizes accurately weighed as above, shall pass into a "twin pug" or other approved form of mixer. In this mixer shall be added a sufficient quantity of Warren's Puritan brand No. bituminous waterproof cement, to thoroughly coat all the particles of stone and to fill all voids in the mixture. The bituminous cement shall, before mixing with the stone, be heated to between 200° and 250° F., the amount used in each batch shall be accurately weighed, and used in such proportion as has been previously determined by laboratory examination to give the best results and to fill the voids in the mineral aggregate. The mixing shall be continued until the combination is a uniform bituminous concrete. In this condition it shall be hauled to the street, and there spread on the prepared foundation to such depth that, after thorough compression with a steam road roller, it shall have a thickness of two inches. The proportioning of the varying sizes of stone and bituminous cement shall be such that the compressed mixture shall as closely as practicable have the solidity and density of solid stone.

(b) SURFACE FINISH.—After rolling the wearing surface there shall be spread over it a thin coating of Warren's quick-drying bituminous flush coat composition, the purpose of this coating being to completely fill any unevenness or honeycomb which may appear in the surface of the mixture.

There shall then be rolled into the surface a thin layer of stone chips for the purpose of presenting a gritty surface which will not be slippery.

(c) GENERAL.—Each layer of the work shall be kept as free as possible from dirt, so that it will unite with the succeeding layer.

The price bid per square yard must include the laying, mixing and furnishing of all materials, labor and implements necessary to complete the foundation and wearing surface.

The bituminous composition or cement shall in each case be free from water, petroleum oil, water gas or process tars, and shall be especially refined with a view to remove the light oil, naphthalene, and other crystalline matter, susceptible to atmospheric influences.

If the fine crushed stone used does not provide the best proportions of fine-grained particles, they must be supplied by the use of not to exceed 15% hydraulic cement, pulverized stone, or very fine sand.

The specifications also state that the Warren Brothers Co. have agreed to furnish all necessary bitumens at a specified price per square yard.

We are indebted to Mr. Josiah Miller, County Engineer, Salem, N. J., for the specification and cross-section of the proposed road. It should be added that, as noted in the columns of "Contract Prices" in our issue of Sept. 10, all bids for the work were rejected.

TREATMENT OF WATER FOR LOCOMOTIVE BOILERS.*

By G. R. Henderson.†

Few improvements in railway operations have excited such uniform interest within the last few years as the systematic treatment of boiler feed waters, and if this makes it possible to maintain our engines longer in service or reduce the cost of repairs by any legitimate means, it is sure to receive attention. When engines were small and not worked to anything like their capacity, a little additional "mud" in the boiler was not given serious thought. When, however, boilers came to be operated for long hours to their limit of evaporative capacity, the

*A paper read at the meeting of the Western Railway Club, Chicago, Sept. 15.

†113 Cass St., Chicago.

question became serious, and the more so as the engine was needed for almost continuous service.

"Washout experts" came to the front and contended that by extreme care (so difficult to enforce among the exigencies of traffic congestion) boilers could be maintained a long time in service. But the very delays due to holding the engine for such careful washouts would sum up, perhaps, more time actually out of service than would ordinarily be imagined.

The next step was to use soda ash in the tender, and so make a treating plant out of the locomotive, necessitating frequent and thorough washing out and blowing out—the latter particularly objectionable in passenger service. Often soda ash was used when the incrustants were carbonates and really needed a simple treatment of lime, but "soda ash" was a standard "cure all," and in it went.

Finally it became evident that better service could be maintained by treating the water before it was taken on the tender, and thus avoid the blowouts and washouts and their various objections. The principal stumbling block was the expense of plants, which runs from $1,000 to $6,000 each, and if bad waters are numerous many such plants will be required.

In order to demonstrate the efficiency of such systems, one Western road covered a stretch of 200 miles in a bad water district by treating tanks so located that the passenger engines would use only treated water, the stations being separated by 50-mile intervals. The freight engines, taking water much more frequently, were not expected to show the same benefit as the passenger engines. In the course of a few months the passenger engines showed by inspection that the old scale was dropping off the firebox sheets and staybolts and that the treatment was becoming effective.

The different waters were doctored with lime or soda ash, or both, as analysis of the water indicated necessary, but the enginemen reported increased trouble from foaming, and further analyses proved that they were correct.

As a rule, boiler waters are found objectionable if containing ingredients that will cause corrosion, incrustation or foaming. Corrosive matter can generally be neutralized, but foaming troubles are difficult to overcome. Oil, tannic acid, liquid hemlock and various boiler compounds have been experimented with, and perhaps the best results have been obtained with the Omaha boiler compound, which seems to quiet the water very effectively without injuring the boiler. If a water contains over 50 grains of foaming matter (soluble salts) to the gallon, it is sure to give trouble in a locomotive.

The incrusting salts must be regarded as of two kinds: carbonates and sulphates. The former, when boiled, give off carbonic acid gas when in excess, and deposit as chalk in a soft, flocculent mass, easily blown out of the boiler. By a previous treatment of slaked lime, the carbonic acid is all combined with lime, allowing the carbonates to deposit while cold in the treating tank instead of in the boiler. In such cases all the carbonates originally in the water, and that which is formed from the added lime, will be deposited by gravity, if the treating solution be of the proper strength, and neither the carbonates nor the treating lime will enter the boiler.

With sulphates, however, the conditions are different. These require soda ash or soda carbonate for their reduction, the reaction producing carbonates and soda sulphate. The carbonates will be deposited, as explained before, but the soda sulphate remains in the solution, enters the boiler, and constitutes a foaming grievance. It does not form scale, but by concentration makes the water so light that it primes and passes over into the cylinders, and at times even prevents blowing the whistle.

Thus we pass from one trouble to another; in fact, one large Western road is following the practice of leaving waters untreated if they would contain 50 grains per gallon of foaming matter after such treatment.

A water may contain 30 grains incrusting and a like quantity of foaming matter to the gallon; the treating of such water (if the incrustants be sulphates) would result in over 60 grains of foaming material, and the road referred to advises that the foaming water seems to search the joints of the boiler much more actively than good water—in other words, causes leaks.

Baryta hydrate has been suggested as a means of preventing foaming, by foaming baryta sulphate, which is insoluble and will precipitate, but its expense is prohibitive. Ordinary treatment of lime and soda ash can be made for from 2 to 6 cts. per 1,000 gallons.

It seems as if the only way in which foaming can be obliterated is by distillation. The cost of this method has generally been considered beyond reason, but by means of an apparatus devised by Professor. Goss, distilled water may be produced for 13 cts. per 1,000 gallons, figuring coal at $1 per ton. In localities where it is necessary to haul water any distance, say 50 miles or more, the still may show a very nice saving, and the cost of the apparatus will not, perhaps, exceed that of the equipment tied up in water service. A model of such an apparatus has been tried on water containing 400 grains per gallon, and has demonstrated its practicability.

It would be well to have each particular water thoroughly studied and find out whether, after treatment, it will be all that is desired, or we may spend considerable money and still be disappointed in our results. These suggestions are not intended in any way as a reflection upon the treatment of waters, as it is believed that railways must come to recognize it as good practice, but it is intended as a caution to those who expect a speedy relief from all boiler troubles, without taking the necessary steps to prevent simply a correlation of trouble.

NOTES FROM THE ENGINEERING SCHOOLS.

PURDUE UNIVERSITY.—The Bureau of Forestry, United States Department of Agriculture, has inaugurated an investigation of the mechanical properties of the commercial timbers of the United States, and has established a Timber Testing Station at Purdue University, La Fayette, Indiana, to form the nucleus of the work in the Mississippi Valley region. Other stations have been established at the University of California, at the Yale Forest School, and at Washington, D. C. This action of the Bureau does not involve the erection of additional buildings, but a more thorough utilization of equipment already existing in the Laboratory for Testing Materials. Additional machines of a special character, however, belonging to the Bureau, will be installed in the laboratory for the needs of this work. The work of this station will be under the direction of Dr. W. K. Hatt, who has recently been appointed to have supervisory charge of the work of all the Timber Testing Stations of the Bureau of Forestry. Responsibilities thus assumed by Dr. Hatt will not interfere with the discharge of his duties at the University.

The immediate work of the Bureau of Forestry at the Purdue station will be a study of the red gum, a wood that is of very widespread growth, and, although possessing valuable properties, is at present largely neglected through prejudice. An investigation will also be made of the strength of packing boxes with a view of standardizing and determining the necessary thickness of box boards in which at present there is such large waste of material. The character of these investigations is in harmony with the work of the Bureau of Forestry, which, through the practical outcome of its program, has gained the support and sympathy of the lumbermen and of consumers of timber.

THE HAY-HERRAN TREATY with Colombia for the construction of the Panama Canal expired on Sept. 22, through failure of the Colombian Senate to ratify it. This leaves the way open for construction of the Nicaragua Canal, as explained in our last week's issue.

THE NEW YORK CITY COMMISSION ON ADDITIONAL water supply has just submitted a progress report, recommending a new gravity supply of 500,000,000 gallons of filtered water a day, delivered at the northern city limits at an elevation of about 300 ft. through an aqueduct in tunnel. Such a supply of upland water would cost about the same as a like amount of filtered water taken from the Hudson River above Poughkeepsie. The supply would be drawn partly from the upper portions of the Fishkill, Wappinger and Roeliff Jansen Kill drainage areas, north of the present Croton supply, and partly from the headwaters of Esopus Creek, in the Catskills, west of the Hudson River. A single aqueduct of 500,000,000 gallons capacity would need to be built for nearly its full length at the outset, but only two reservoirs need be constructed at first. It is estimated that the aqueduct of full capacity, and dams, reservoirs, filters, land and water rights sufficient for a daily supply of 200,000,000 gallons would cost $50,000,000, and that the construction of such works would require five years from the date of beginning the same. The commission strongly recommends that the city at once begin to construct filters for all the water now drawn from surface sources, including the Croton. The water resources of Long Island, the commission believes, should be developed to their fullest extent, but these, without extension to Suffolk Co. (now prohibited by state legislation.—Ed.) will not be more than sufficient for the growing needs of the Long Island territory within Greater New York until such a time as more water can be introduced from the north. There being no quickly available near by supplementary supply to make up for the deficit already existing in times of greatest recorded drought, the commission urges "water waste prevention in strongest terms," pending the completion of new works. The report is addressed to Mr. Robert Grier Monroe, Commissioner of Water Supply, Gas and Electricity, and is signed by the three members of the commission: Wm. H. Burr, Chairman; Rudolph Hering, and John R. Freeman, Mems. Am. Soc. C. E.

FURTHER WATER PURIFICATION EXPERIMENTS at Springfield, Mass., are being conducted under the direction of Mr. Geo. W. Fuller, Assoc. M. Am. Soc. C. E., of Hering & Fuller, New York City. The earlier experiments were carried on from December, 1900, to Feb. 1, 1902, and were outlined briefly on p. 301 of our issue of April 17, 1902. The water treated was from the Ludlow reservoir, notorious for its occasional bad tastes and odors, and also from Jabish Brook. It was found that double slow sand filtration would remove the tastes and odors when the water was at its worst, and that for the greater part of the time single filtration was adequate. The State Board of Health, however, recommended an unfiltered supply from the Westfield River, stating that the present supply, filtered or unfiltered, would not be adequate for more than ten years longer. The filters used in 1900-1 made use of 5 ft. of sand above the underdrains. At the request of this journal Mr. Fuller has sent us a brief description of the present experimental plant, as follows:

We have erected at Ludlow reservoir a small testing station consisting of six wooden tanks, each 4 ft. in diameter. Three of these on an upper level are for the purpose of giving the water a preliminary treatment, and the three lower ones are plain sand filters containing 3 ft. in depth of the same sand which was used during the tests at Ludlow during 1901. These sand filters are exactly alike in construction, and are operated at rates of 3,000,000, 6,500,000 and 10,000,000 gallons per acre daily. They each receive water from one of the preliminary filters after it has been aerated. As to the preliminary filters, two of them are plain mechanical filters operated without any coagulant whatever, one at a rate of 60,000,000 gallons per acre per 24 hours and the other at double that rate. The third preliminary filter is a coke and sponge scrubber, according to the ideas of Mr. P. Maignen, which have been studied very carefully at Philadelphia, and of course is an upward filtration process. The rate is 60,000,000 gallons per acre daily. At the bottom there are 24 ins. of graded coke, the coarser particles being at the bottom, above which there is a compressed layer of sponge clippings 6 lbs. per sq. ft., making a thickness of approximately 14 ins. This constitutes, with the wash-water tank, a gasoline engine and centrifugal pump and pumping facilities, the testing station as erected at Ludlow.

Thinking that we might not encounter at Ludlow water which would enable the preliminary filters to show their merit or demerit, a duplicate station was built at Belchertown reservoir. The only difference is that instead of having two plain mechanical filters there are two scrubbers, the duplicate scrubber being operated at the rate of 120,000,000 gallons per acre daily, or double the regular rate adopted in these tests for preliminary filters.

The plant at Ludlow has been in operation practically continuously since the first of August. The one at Belchertown was started about the middle of August.

A SPEED OF 114 MILES AN HOUR is said to have been reached by an experimental electric car on the Berlin-Zossen military railroad on Sept. 19. According to press dispatches the track on which this speed was attained was laid with rail a little over 100 lbs. weight, supported on pine ties faced with oak, spaced as close together as possible and ballasted with broken stone.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision on the Monongahela Ry., near Brownsville, Pa., on Sept. 20. An engine ran into the rear of a freight train which was standing on the main track. Two men were killed. Fog and failure to protect the train by backflagging are said to be responsible for the accident.——On Sept. 16 occurred a butting collision between two freight trains on the Intercolonial Ry., at St. Madeline, Quebec, because of an incorrect train order. Two men were killed.——Delayed reports of railway accidents during the preceding week tell of several bad wrecks. An excursion train on the Chicago, St. Paul, Minneapolis & Omaha Ry. was ditched by a washout, near Eau Claire, Wis., on Sept. 12, and four passengers were killed. The rainstorms prevailing over the Northwest on Sept. 11 and 12, it is reported, caused scores of washouts and interruptions to traffic. A remarkable accident is reported from Beaumont Jc., Kan. On Sept. 10 a car full of dynamite on the St. Louis & San Francisco R. R. ran away down grade while being shifted, and finally collided with an engine. The dynamite exploded; three of the injured died within a few hours.

ALKALI HAS RUINED about 600,000 acres of lands at present under irrigation in the arid region of the United States, according to a statement by Secretary Wilson of the Department of Agriculture at the National Irrigation Congress. The Bureau of Plant Industry is therefore conducting experiments with plants which can grow on alkaline soils.

LIGHT BUOYS USING ELECTRIC LIGHT, several of which have been used for some years in New York harbor to mark the ship channel in the lower bay, have now been abandoned, and the power station on Sandy Hook which supplied them with current has been closed. The electric buoys have given more or less trouble, mainly because of damaging and breaking of the supply cables by ice or other causes. They have been replaced by the regular style of Pintsch gas buoy.

RIVER TRANSPORTATION OF FREIGHT in Chicago is being proposed to relieve the congested street traffic and the delays due to hauling heavy loads of freight over the ill-paved streets. The plan is to tow lighters on the river between the freight yards, warehouses, and manufacturing establishments which have river frontage. There is no definite plant yet, and it is uncertain what amount of freight is handled between these particular points.